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Drug Calculation: Do Calculators Make a Difference on Drug Calculation Outcomes for Nursing Students?

BY

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SUMMARY

Medication errors have serious consequences for patient safety (Coyne, Needham & Rands, 2013). Safe medication administration is an important skill provided by the nurse. Thirty to forty percent of all medication errors are related to inaccurate dosage calculations resulting from poor arithmetic skills and an inability to conceptualize drug calculations (McMullen, Jones & Lea, 2010). For nursing students, medication errors are a source of anxiety and decreased self-efficacy (Mackie & Bruce, 2016). It is the responsibility of nursing educational institutions to ensure that their graduates are able to safely prepare and administer medication (Coyne, Needham & Rands, 2013).

This quantitative study used Cognitive Load Theory and Bandura's Self-efficacy theory, to investigate the relationship between calculator use and the responses of John Abbott College (JAC) nursing students to questions on a practice medication administration quiz. Specifically, it sought to replicate previously found results - that calculator use was associated with fewer arithmetic errors and more conceptual errors on drug calculation problems (Shockley, McGurn, Gunning, Graveley & Tillotson, 1989). In addition this study endeavored to determine if calculator use is related to student self-efficacy and anxiety related to drug calculations.

A quasi-experimental design was carried out in Fall 2017 at JAC. A convenience sample of one hundred and four students in the second and third year of the nursing program completed two versions of a practice drug calculation quiz (PMAQ) with and without a calculator. They then completed a Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) to determine the effect of the calculator on these two variables. The PMAQ reflected the difficulty of calculations and the conceptual challenge appropriate for the respective semester level of the student. Data collected from the PMAQ were analyzed using a t-test to determine if there was a statistical difference in performing drug calculations with or without a calculator. Similarly a Chi-square test was used to determine if there was a difference in anxiety and self-efficacy when a calculator was used to perform drug calculations. Ethics approval from the JAC ethics committee was obtained for this research.

The results indicated that overall students had better drug calculation outcomes when they used a calculator. There was no significant difference in conceptualization skills when a calculator was used except in the variable "concept not understood" (errors that could not be explained, questions that were incomplete or left out) which showed significant improvement. This could be related to the increased self-efficacy and decreased anxiety students reported when calculators were used for drug calculations.

The wording used for the survey questions limited the type of analyses that could be performed, as the variables (calculator, self-efficacy and anxiety) were embedded in the questions and could not be compared with each other in a correlational analysis. In future research the design could be improved to include a questionnaire after each version of the test. Expanding the study to include students

from other colleges will ensure transferability of the results. Interviews from students and teachers could also be included to broaden the scope of the research.

In conclusion calculators have a positive effect on drug calculation outcomes and student self-efficacy and anxiety related to drug calculations. The effect on conceptualization skills remains unclear. One third of drug calculation errors are conceptual (Mackie & Bruce, 2016). Teachers should therefore incorporate strategies to increase conceptualization skills as it relates to drug calculations. Testing a student's drug calculation ability should take place after they have had the opportunity to develop their conceptualization skills through simulation and/or clinical experience. Visualization (a component of conceptualization) has been identified as an essential skill to accurately perform drug calculations (Grugnetti, Bagnasco, Rosa & Sasso, 2014) and this can be improved through well-designed simulation (Pauly-O'Neill, 2009).

RÉSUMÉ

Les erreurs de médication ont de sérieuses conséquences sur la sécurité des patients. (Coyne, Needham & Rands, 2013). Une administration sécuritaire de médicament est une compétence pertinente donnée par l'infirmière. Trente à quarante pourcents de toutes les erreurs médicamenteuses est dû à une erreur de calcul des dosages, ceci est la résultante d'une faiblesse du calcul arithmétique et une incapacité de conceptualiser les calculs de dosage de médicaments. (McMullen, Jones & Lea, 2010). Les erreurs de médications sont une grande source d'anxiété pour les étudiants(es) infirmiers(es) et une diminution de l'efficacité de ceux-ci. (Mackie & Bruce, 2016). C'est la responsabilité des centres d'enseignement des soins infirmiers de s'assurer que les finissants(es) sont capables de préparer et d'administrer les médicaments de façon sécuritaire. (Coyne, Needham & Rands, 2013).

Cette recherche quantitative a utilisé la théorie ''Cognitive Load Theory and Bandura's Self-efficacy'', pour étudier la relation entre l'utilisation de la calculatrice et les réponses des étudiants(es) infirmiers(es) du Collège John Abbott d'un test pratique sur l'administration de médicaments. Cette étude vise à reproduire des résultats similaires : que l'usage de la calculatrice est associé à moins d'erreurs de calcul arithmétique et à plus d'erreurs de conceptualisation de calcul de dosage (Shockley, McGurn, Gunning, Gravely & Tillotson, 1989). En plus, cette recherche s'efforcera à déterminer si l'utilisation de la calculatrice aura une influence sur l'efficacité de l'étudiant et l'anxiété reliée aux calculs de dosage de médicaments.

Une conception quasi expérimentale a été utilisée durant la session d'automne 2017 au collège. Un échantillon de cent quatre étudiants de deuxième et de troisième année de Nursing ont répondu à deux versions d'un test pratique de calcul mathématique (PMAQ), l'un avec une calculatrice et l'autre sans calculatrice. Ensuite, ils ont répondu à un ''Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) '' pour déterminer l'effet de la calculatrice sur ces deux variables. Le PMAQ démontre la difficulté qu'ont les étudiants(es) à calculer et le défi de conceptualisation approprié à chaque niveau de l'étudiant. La collecte de données du MAQ a été analysée, utilisant le T-Test, pour déterminer s'il y a une différence statistique à l'utilisation ou non de la calculatrice. Simultanément, un ''Chi-square test'' a été utilisé pour voir s'il y avait une différence entre l'anxiété et l'efficacité de l'étudiant quand une calculatrice est utilisée pour faire les calculs de dosage médicamentaire. Le comité d'éthique du Collège John Abbott a donné son assentiment pour cette recherche.

La formulation du questionnaire a limité le type d'analyse qui aurait pu être fait, à cause des variables (la calculatrice, efficacité de l'étudiant et l'anxiété) qui étaient inclus dans les questions et ne pouvaient pas être comparées. Pour les prochaines études sur ce sujet, une meilleure conception de celle-ci devrait inclure un questionnaire après chaque test. Aussi l'étude pourrait se faire avec la participation des autres Cégeps cela donnerait la transmissibilité des résultats. Pour élargir le spectre de la recherche, des entrevues avec les étudiants(es) et les professeurs pourraient être faites.

Pour résumer, l'utilisation de la calculatrice a un effet positif pour le calcul de dosage de médicaments et sur l'efficacité de l'étudiant(e) ainsi que sur l'anxiété causé par ce calcul. Les effets sur la compétence de conceptualisation restent obscurs. Le tiers des erreurs de calcul des médicaments sont conceptuels (Mackie & Bruce, 2016). Les professeurs devraient incorporer des stratégies pour améliorer les aptitudes de conceptualisation car elles sont inhérentes au calcul des médicaments. Vérifier l'habileté de l'étudiant(e) à faire des calculs exacts devrait se faire après les stages cliniques ou la simulation, ceux-ci leur permettent de développer leur aptitude de conceptualisation. La visualisation (une composante de la conceptualisation) a été identifiée comme une compétence essentielle pour faire des calculs exacts de médicament (Grugnetti, Bagnasco, Rosa & Sasso, 2014) et peuvent être améliorée pendant une séance de simulation (Pauly-O'Neill,2009)

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LIST OF ABBREVIATIONS

JAC	John Abbott College
MAQ	Medication Administration Quiz
MSEAQ	Mathematics Self-Efficacy and Anxiety Questionnaire
OIIQ	Ordre des infirmières et des infirmiers du Québec
PMAQ	Practice Medication Administration Quiz

DEDICATION

To my children Matthew and Chiara: persevere and make your dreams a reality!

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This research project would have been impossible without the support of the faculty, staff and students of the JAC nursing department. In particular I would like to thank Tia Nymark, Jane Pearsall, Janet Morrison, Susan Young and Judy Sabiston for their unwavering support and encouragement throughout this process. Richard Masters assistance in the analysis of the results of this project was invaluable and I am truly grateful for his dedication to this project.

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INTRODUCTION

Nurses work on an interdisciplinary team and together the team is responsible for patient safety. However, when it comes to medication administration, the burden of safety rests with the nurse, as it is the nurse who performs the last verification that the right medication and dosage is administered (Truchon, 2004). Thirty to forty percent of medication errors are related to calculation errors (McMullan, Jones & Lea, 2010). With this in mind, nursing schools shoulder the responsibility of ensuring that student nurses are competent in drug calculations before graduating.

Calculation errors are related to both difficulties with arithmetic skills as well as with the inability to conceptualize the drug calculation (McMullan et al., 2010). Conceptualization includes the ability to understand a prescription, interpret drug labels and medication records and use the appropriate information to set up a drug calculation (Mackie & Bruce, 2016). Nursing students internationally struggle with drug calculations (Bagnasco et al., 2016; McMullan et al., 2010), which is also a source of anxiety and low self-efficacy for many students (Mackie & Bruce, 2016). For example, anxiety and self-efficacy are related to performance outcomes (McMullan et al., 2010; Ramirez, Gunderson, Levine & Beilock, 2013; Rana & Mahmood, 2010). Students with high test anxiety experience more difficulty encoding information as a result of cognitive interference from worrying (Rana & Mahmood, 2010). Students who are significantly less confident and more anxious in performing drug calculations have challenges with numeracy (McMullan et al., 2010). These findings highlight the need for nursing schools to find strategies to improve drug calculation outcomes, decrease anxiety and increase self-efficacy related to drug calculations.

One strategy to improve drug calculation outcomes that has been studied is the use of calculators for drug calculations. Calculators have been found to decrease arithmetic errors (Murphy & Graveley, 1990; Shockley et al., 1989) but their effect on conceptual errors remains inconclusive. Shockley et al., (1989) reported an increase in conceptual errors when a calculator was used for drug calculations whereas Murphy & Graveley, (1990) reported that students made fewer errors in

setting up the drug calculations when using a calculator. Few studies have looked at the effect of calculator use on self-efficacy and anxiety related to drug calculations. The purpose of this study is to investigate the relationship between calculator use and drug calculation outcomes, self-efficacy, and anxiety for JAC nursing students.

One hundred and twenty-nine second and third year students enrolled in the John Abbott College Nursing program in Fall 2017 were invited to participate in this research. This study used a quasi-experimental approach to explore the effect of the calculator on drug calculation outcomes. A practice medication administration quiz was administered with and without a calculator and the results were analyzed using a t-test. A mathematics self-efficacy and anxiety questionnaire (MSEAQ) was also administered and the data analyzed using a Chi-square test.

Implications

The findings of this research study aimed at identifying strategies and implications for future education practice and research regarding enhancing student success of drug calculations and at ultimately improving patient safety.

CHAPTER ONE

PROBLEM STATEMENT

Errors in dosage calculations can cause serious harm to the patient and in some cases death (Mackie & Bruce, 2016; McMullan, Jones & Lea, 2012). Numeracy is an essential skill used by nurses to perform several of their routine functions safely. Numeracy is defined as the ability to conceptualize the problem, perform a correct calculation and accurately interpret the results obtained (Mackie & Bruce, 2016). Numeracy is used to monitor the fluid balance of the patient as well as to regulate the flow of intravenous fluid. Most importantly, numeracy is essential for medication administration as nurses spend 40% of their time during a shift preparing medication (Mackie & Bruce 2016). Nurses are expected to calculate and verify medication dosages each time they administer medication. They provide the last verification that the right dose of the medication is prescribed and that the correct amount of medication to deliver this dose, is prepared and administered. This requires conceptualization of the drug calculation which involves understanding the components of a prescription, drug label and medication sheet as well as being able to identify the information required to solve the drug calculation (Mackie & Bruce, 2016). It also involves basic arithmetic skills such as addition, subtraction, multiplication and division and accurate interpretation of the result. However for some nurses, when these are coupled with fractions, decimals and unit conversions, it presents computation difficulties (Mackie & Bruce, 2016). Moreover, the complexity of the drug calculations can increase in various clinical settings. For example, when the nurse is caring for newborns and children, preparation errors increase in frequency from 27% to 60% (Bagnasco et al., 2016). In an effort to prevent errors in dosage calculations nurses in the clinical setting will often use a calculator when computing drug dosages.

The Ordre des infirmières et des infirmiers du Québec (OIIQ) test nursing students' medication knowledge during their licensing exam, however it is the responsibility of nursing programs to develop mechanisms for verifying that nursing students can perform the drug calculations required to safely prepare and administer

medication. To ensure that students have achieved the numeracy skill level that enables them to safely prepare medications, many nursing schools require them to take a drug calculation test before graduating. This test usually requires that students achieve a high percentage to pass. Failure may mean an inability to complete the program or at least a delay in graduation (Roykenes, Smith & Larsen, 2014).

John Abbott College is 1 of 4 English CEGEPS in Quebec that offer studies in nursing. Students come to the John Abbott College (JAC) nursing program from diverse cultural and educational backgrounds and their mathematics skills are varied. Some students have not worked with fractions or decimals for a number of years or have grown accustomed to using calculators to solve math problems and may not understand how these concepts apply to drug calculations. They worry about their basic math skills, with some students stating that they are “just not good with math”.

In each of the six semesters of the JAC nursing program, students receive instruction on the type of drug calculations they are expected to perform during that semester. A medication administration quiz (MAQ) is then administered to test students’ safety for drug administration. The MAQ in each semester reflects the difficulty of drug calculations that is expected for the level of student. A minimum score of 80% is required to pass the MAQ. There are students in every semester who find the MAQ challenging and for these students; a second opportunity to demonstrate proficiency in drug calculations is given at a later date during the semester. Failure at this point may lead to failure of the course. An average of 45% of third year students fail the MAQ on their first attempt.

The nursing program at JAC maintained over the years that students must show all work for their drug calculations and that calculator use for drug calculations hinders the development of the conceptualization skills required for accurate dosage calculations. However, in the fall of 2016, faculty in the nursing department decided to allow second and third year students to use calculators for drug calculations on quizzes, exams, and in the clinical setting, beginning in winter 2017. It was felt that since the Ordre des infirmières et des infirmiers du Québec (OIIQ) had moved to the

use of calculators in their licensing exam several years ago, our nursing students should be allowed to use calculators to better prepare for this exam.

Anecdotally, student anxiety around these drug calculation tests is generally high. In the weeks and days before the test, students spend hours in teachers' offices or in tutoring, practicing questions, reviewing how to work with fractions and decimals, and how to perform long division. Their anxiety is high and their self-efficacy low. This is consistent with research conducted by Shapiro (2014) who found that test anxiety among nursing students is higher than among students in other health disciplines. This could be due to the demanding nursing curriculum. Varying pre-admission math ability across the disciplines may also account for the difference in anxiety. Walsh (2008) also reported that nursing students' experienced low self-efficacy related to solving math problems. Students who fail the test because of errors with manipulation of fractions and placement of the decimal are often frustrated. Many of these students indicate that if they were able to use a calculator then these errors would be eliminated.

This entire process represents the high anxiety and low self-efficacy that many students experience in preparing for drug calculation tests'. Both anxiety and low self-efficacy have been identified as barriers to success in drug calculation tests (Mackie & Bruce, 2016). Anxiety, usually expressed as worry, can affect a student's capacity to learn and uses up the working memory needed to solve the drug calculation problems. Low self-efficacy can affect their confidence and motivation to prepare for and perform the drug calculations.

The use of calculators in drug calculations is controversial. One study found no significant difference between drug calculation outcomes with or without the use of a calculator (Tarnow & Werst, 2000). Conversely, other studies found that calculators have been shown to improve basic math calculation (Bagnasco et al., 2016; Pentin & Smith, 2006) but to increase errors related to the conceptualization of the problem (Shockley et al., 1989). Conceptualization is important as it guides the students to the mathematical functions required to perform the drug calculation. It is also used in

determining if the result is realistic given the context in which the medication will be given.

Since drug calculations are so important to patient safety, and the literature on drug calculations appears to be inconclusive, a study of the effect of calculator use on math calculation outcomes and conceptualization skills is warranted (Dopson, 2008; Shockley et al., 1989). The relationship between the use of the calculator and anxiety and self-efficacy related to math is also unclear. This study therefore, explored the influence of using a calculator on students' anxiety and self-efficacy related to the drug calculation test, as well as its relationship to their drug calculation arithmetic outcomes and conceptualization skills.

In Quebec the entry to nursing practice is at the Collège d'enseignment general et professionnel (CEGEP) level. A CEGEP is equivalent to a community college and offers both pre-university programs and technical programs that lead to entry to the workforce (Government of Canada, 2012). CEGEP nurses comprise 60% of all the nurses in Quebec (Ordre des infirmières et des infirmier du Quebec, 2016). Since no articles investigating the CEGEP level nurse was found, this research investigated the effect of the use of a calculator on drug calculation outcomes of the CEGEP level nurse particularly the student nurses at JAC.

CHAPTER TWO
CONCEPTUAL FRAMEWORK

There are many factors that influence nursing students' success on drug calculation tests. To help us understand the two predispositions (anxiety and self-efficacy) studied in this research, two theories were used to develop the conceptual framework - Bandura's self-efficacy theory and Cognitive Load Theory.

Cognitive Load Theory explains the effect of anxiety on the ability to recall information needed to solve drug calculations and this affects performance outcomes. Students need to recall and apply the concepts, formulae, and arithmetic functions needed for the given medication administration situation. Bandura's self-efficacy theory relates self-efficacy to the student's performance. These two theories are considered, as they are the key characteristics that the John Abbott College nursing students display around drug calculations.

2.1 Cognitive Load Theory

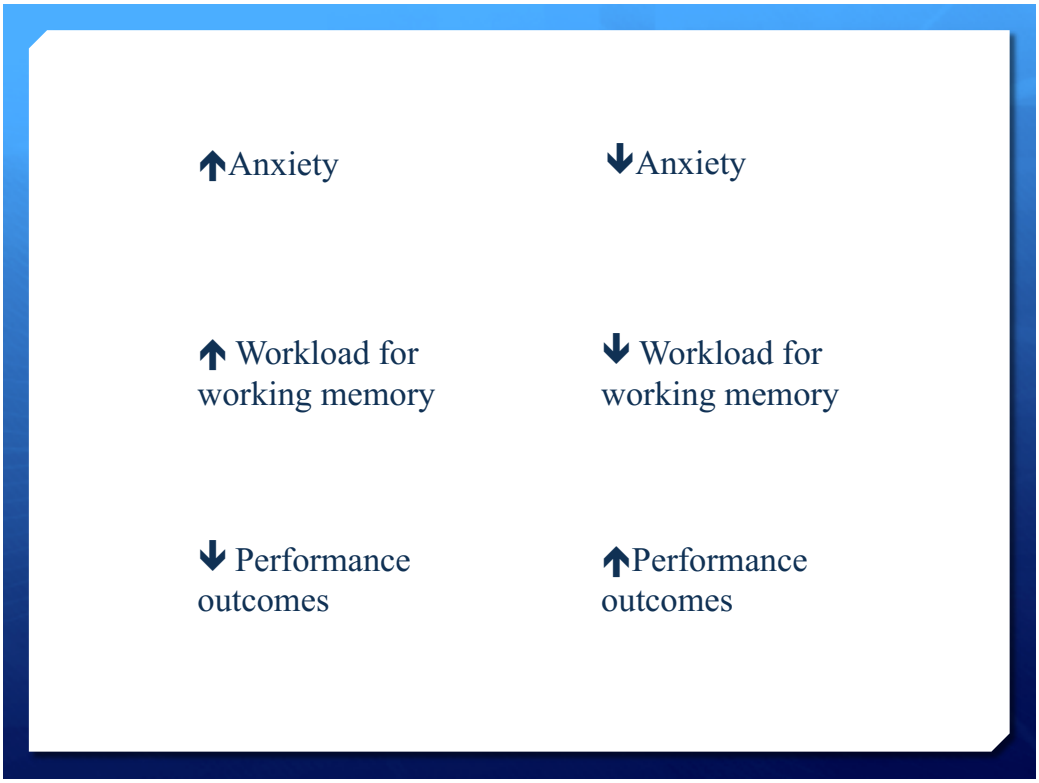
Cognitive Load Theory states that there are two types of memory that are used to store information: the working memory and the long-term memory. The working memory has a small capacity and is of short duration. The working memory is used when learning new information. It is also engaged to temporarily store information that is needed immediately for an ongoing task (Shi & Liu, 2016). The long-term memory uses cognitive schemas to store information. Cognitive schemas can be combined to form larger pieces of information that can be stored as one unit of information to be used together for a specific function. The use of the long-term memory decreases the workload of the working memory and allows it to process larger amounts of information than it would normally. The goal of cognitive load theory is to make the working memory and the long-term memory work together more efficiently (Pass & Ayres, 2014).

Students with math anxiety often worry about failure particularly in tests where failure can have dire outcomes. These worrying thoughts compete for the working memory, decreasing its capacity to be used to store information for the math problems themselves (Gunderson, Levine & Beilock, 2013; Pass & Ayres, 2014; Shi

& Liu, 2016) (Figure 1). This similar type of anxiety has been observed in our nursing program, as the stakes are high in this math test and could affect their success in the program and ultimately them obtaining their professional license. Using a calculator for drug calculations may decrease their anxiety and worry, thus freeing the working memory to perform more efficiently.

Figure 1

Using Cognitive Load Theory to show how anxiety can affect performance outcomes.



2.2 Bandura's Self-efficacy theory

Social learning theory looks at how behaviours develop and how they can be changed. Albert Bandura believed that behaviour was influenced by environmental as well as cognitive factors. One of these cognitive factors he calls self-efficacy and defines it as the individual's belief that they can succeed (Wulfert, 2016). He suggests that self-efficacy is the most important factor in behaviour regulation. When self-efficacy is high, performance outcomes are also better (Bandura, 1977). There are four factors that influence self-efficacy; previous accomplishments in a similar task,

observing others succeed at the task, verbal persuasion and emotional arousal. Previous accomplishment in a similar task is the most influential factor on one's self-efficacy (Bandura, 1977).

Many nursing students struggle with drug calculation (Mackie & Bruce, 2016) and lack confidence about their ability to succeed (Roykenes, 2016). Many of the students entering our nursing program today indicate that they are more familiar with executing math calculations with the use of a calculator than without it. By applying the self-efficacy theory, it suggests that if students are allowed to use a calculator for drug calculations, they will be more comfortable performing the calculations and have a more positive experience. This suggests an increased self-efficacy related to drug calculations and better performance outcomes (Figure 2).

Figure 2

Using Bandura's self-efficacy theory to show the relationship between previous experience and performance outcomes.

2.3 Research Question and Hypothesis

This research investigated the effects of using a calculator for drug calculations on drug calculation outcomes and on self-efficacy and anxiety related to drug calculations. It attempted to investigate if calculator use was related to improved drug calculation outcomes for the JAC nursing student cohort and also to expanded it to explore the effect of calculator use on the anxiety and self-efficacy related to drug calculations of JAC nursing students. There were four dependant variables namely:

- Drug calculation arithmetic outcomes
- Drug calculation conceptualization skills.
- Math self-efficacy and,
- Math test anxiety,

The calculator was the only independent variable. The research question that leads to this study was therefore "What is the effect of calculator use on drug calculation outcomes for 2nd and 3rd year nursing students enrolled in JAC nursing program. This research question will be addressed by looking at the following four specific relationships:

1. Does calculator use result in a difference in drug calculation arithmetic outcomes?

2. Does calculator use result in a difference in drug calculation conceptualization skills?

3. Does calculator use result in a difference in math self-efficacy?

4 Does calculator use result in a difference in math test anxiety?

Using these questions and from a preliminary review of the literature, it was hypothesized that:

H_1 Drug calculation arithmetic outcomes are different for students who use a calculator than for students who do not use a calculator.

H_2 Drug calculation conceptualization skills are different for students who use a calculator than for students who do not use a calculator.

H_3 The level of math self-efficacy is different for students who use a calculator than for students who do not use a calculator.

H_4 The level of math test anxiety is different for students who use a calculator than for students who do not use a calculator.

Based on the proposed research questions, the bodies of literature that were reviewed in more depth included: articles that reported on test anxiety and academic performance, math test anxiety as it relates to nursing students, math tests and its effect on a student's self-efficacy, as well as drug calculation and the use of calculators.

CHAPTER THREE
LITERATURE REVIEW

A review of the literature is an important first step in order to understand the current state of knowledge concerning the effect of calculators on drug calculation outcomes for nursing students. An area of interest and concern for the faculty of the John Abbott Nursing department is the performance of our nursing students on drug calculation tests as it is a fundamental competency nursing students must achieve in order to succeed in the program. The use of calculators for these drug calculation tests has only recently been introduced into the 2nd and 3rd year of our program in an attempt to align the department's practices with the format of the nursing licensing exam. It was felt by the JAC nursing faculty that the first year students should not use a calculator, as it was their first exposure to drug calculations. It was feared that the calculator would hinder the development of their conceptualization skills.

A comprehensive search of the literature was conducted using several databases such as CINHAL, Science Direct, Ebscohost and Ovid. Key words used in various combinations included drug calculations, calculator, self-efficacy, anxiety, math anxiety, nursing, and nursing students. There were several studies that investigated drug calculation performance in nursing students. Conceptualization ability, anxiety and self-efficacy were factors related to calculation outcomes.

Of the articles reviewed, eight articles were identified that addressed the key concepts related to the research questions (see Appendix A). The first section of the literature review will discuss the broader study concepts. The second section compares and contrasts these eight articles according to their design, sample and methodology. This will provide an important background on how this present study was conceptualized as well as summarize the gaps and the need for this study and research question.

3.1 Broader Study Concepts Test anxiety and academic performance.

Tests in general create anxiety in students. Students who experience test anxiety can have negative thoughts about their ability to pass the test and may even feel fearful and helpless (Shapiro, 2014). This anxiety has a direct influence on

students' academic performance, with increased levels of anxiety leading to lower academic performances (Rana & Mahmood, 2010). However, tests that require the achievement of a high percentage to pass create even greater levels of anxiety. At JAC students must achieve a minimum of 80% on their drug calculation test to pass the MAQ.

Test anxiety makes the student perceive the test as threatening. This causes physiological responses such as butterflies in the stomach and cognitive responses such as negative thoughts (worry) about the test and feelings of apprehension (Rana & Mahmood, 2010; Shapiro, 2014). These thoughts interfere with the student's capacity to learn before the test (Shapiro, 2014) and uses up the working memory during the test making it unavailable for use to solve test questions (Paas & Ayres, 2014).

Math test anxiety and nursing students. Test anxiety in nursing students is higher than in students pursuing an education in other health disciplines (Shapiro 2014), with as many as 30% of all nursing students indicating that they suffered from test anxiety. This may be related to the demands of the nursing program (Shapiro, 2014) but also to the varying admission requirements across disciplines. For example, prospective pharmacy students are required to have a strong foundation in math and science including calculus prior to entry (Broedel-Zaugg et. al., 2008). This is also consistent with medical student requirements. However, some university nursing programs only require pre-calculus math as program entry requirement. For the CEGEP level nursing programs, the requirement is secondary IV math although secondary V math is recommended ("Dawson College," n.p., "John Abbott College" n.p.). Moreover, the literature found on this topic focuses predominantly on the nursing profession in terms of math test anxiety as administering and delivering medications is a fundamental core competency of this professional discipline. This is not the case for other health care disciplines such as medicine where prescribing medication is the core competency. More recently, drug calculation ability has been addressed among emergency medicine and paramedic training. Results from a pilot study by Boyle and Eastwood (2018), revealed that paramedic's ability to undertake

mathematical and drug calculations without a calculator also varies, with some results highlighting the paramedics mathematical skills as a potential risk to patient safety. However, studies relating to math test anxiety and/or self-efficacy with respect to drug calculations were not identified within these other disciplines.

In addition, almost 50% of first year nursing students are anxious about math. Mackie and Bruce (2016) noted that more than 50% of nursing students' worldwide fail the drug calculation test. This anxiety could be related to several factors such as the students' confidence about math (McMullan et al., 2012), their past experience with math (Roykenes, 2016), as well as the high pass mark and the consequences of failing the math test (Roykenes et al., 2014).

Math test and self-efficacy. When a student fails a math test, this can lead to further anxiety and a decrease in math self-efficacy (McMullan et al., 2012). The self-efficacy of nursing students related to solving math problems is generally low (Walsh, 2008) and this can have an effect on whether a student becomes anxious about a test or not (Roykenes et al., 2014). There is an inverse relationship between anxiety and self-efficacy and a direct relationship between a student's math self-efficacy and their performance on math tests (McMullan et al., 2012). Students who have low self-efficacy interpret the physiological responses to anxiety as signs that they are unable to succeed (McMullan et al., 2012), increasing their belief that they will perform poorly on the drug calculation test.

Drug calculation and the use of calculators. Anxiety and low self-efficacy are both identified as barriers to success in drug calculation tests (Mackie & Bruce, 2016). Teachers and students at nursing schools across Canada agree that drug calculation is a problem for aspiring nurses (Mackie & Bruce, 2016). Student participants in a study by Walsh and colleagues (2008) reported that their anxiety about the drug calculation test was related to the consequences of failing and the limited number of opportunities to retake the test. Findings from other research noted that conceptualizing the drug calculation problem was challenging for some nursing students (Shockley et al.), while other students demonstrated genuine difficulty

carrying out the mathematic functions required to perform the drug calculations (Mackie & Bruce, 2016).

Math skills required for solving drug calculations include multiplication, division, working with fractions and decimals, and unit changes (Mackie & Bruce, 2016; Shockley et al., 1989). However, accurately performing drug calculations requires more than math skills, it requires the ability to use deduction, reasoning, logic, and understanding (Bagnasco et al., 2016). Nursing students use these conceptual abilities to understand a medication prescription, interpret medication monographs, identify the correct data for the calculation, set up the problem accurately, and interpret the result of the calculation (Mackie & Bruce, 2016). According to the Cognitive Load Theory, for a student to accurately conceptualize a drug problem and use the math skills required to solve the drug calculation, the long-term memory and the working memory must be working together.

3.2 Comparison of key articles and gaps in the research

Using specific key terms, a comprehensive search of the literature was conducted. Eight articles were identified that address the key concepts related to the research question. The literature matrix presented in Appendix A compares and contrasts seven of these articles. The eighth article was a systematic review of ten articles that compared and contrasted test anxiety among nursing students. Studies were compared to illustrate the gaps in previous research namely the target population commonly addressed as well as aspects of research methods and design used.

The studies selected for in-depth review consisted of participants who were nursing students, as this will be the population of interest for my research. Sample size varied from n=38 to n=414. Three studies investigated the use of calculators on drug calculation outcomes and two articles included anxiety (math anxiety or test anxiety) as one of their variables.

Participants. Most of the study participants in the articles reviewed were nursing students in an undergraduate program. There were no studies that investigated drug calculations for the CEGEP level-nursing student. CEGEP nurses

comprise 60% of all the nurses in Quebec (Ordre des infirmières et des infirmier du Quebec, 2016). Research investigating this cohort will complement studies already done in this field. Furthermore, there were no articles with a focus on students in their paediatric rotation. This is particularly important as there are multiple steps required in pediatric drug calculations and this presents an increased risk for drug calculation errors (Bagnasco et al., 2016). It is therefore also important to study the effect of calculator use on drug calculation outcomes for the pediatric nursing student. Although senior nursing students were studied in one article reviewed, pediatric drug calculations were not included (Murphy & Graveley, 1990).

Methodology. A systematic literature review of ten studies conducted by Shapiro (2014) focused on anxiety in nurses. The author found that many of the studies were quantitative using a quasi-experimental design. One of the gaps identified was a lack of reported correlational data between test anxiety and the independent variable. However from this review and comparison of seven articles, quantitative data was collected in various ways for a variety of purposes. Five of the articles presented in the Appendix A, used drug calculation tests to gather quantitative data. McMullan et al. (2012) investigated the relationship between math anxiety, drug calculation self-efficacy, and numerical ability, on calculation ability. Mackie and Bruce (2016) analyzed the drug calculation tests for types of calculation errors made. Another study investigated the effect of the option to use a calculator on drug calculation outcomes. Students who had the option to use a calculator for drug calculation outcomes had fewer set up and calculation errors, and overall exam scores were not significantly different (Murphy & Graveley, 1990). Two studies examined the relationship between calculator use and drug calculation outcomes however their findings were different. In the first study, no significant difference was noted in the number of students attaining a passing grade with or without the use of a calculator for the drug calculations (Tarnow & Werst, 2000). In the second research study, calculators were associated with fewer arithmetic errors but increased conceptual errors (Shockley et al., 1989). There have not been any recent studies on the effect of calculator use on math conceptual ability, related to drug calculations.

In addition, the studies conducted by Roykenes et al. (2014) and Mackie and Bruce (2016), used interviews as a method for gathering data from a representative sample of the participants. These interviews captured the students' perceptions of using a calculator for drug calculations. Due to time constraints and limited resources interviews will not be conducted in this study. A follow up study using interviews to further develop strategies to improve drug calculation outcomes may be needed.

Finally, two studies investigated the relationship of anxiety and self-efficacy in nursing students to drug calculation outcomes, but no interventions to decrease anxiety or increase self-efficacy in relation to drug calculations were explored. Two studies investigated the effect of calculators on arithmetic and conceptual skills but did not look at its effect on anxiety and self-efficacy.

3.3 Summary.

From this literature review, the effect of calculator use on drug calculation outcomes was inconclusive. For example some studies asserted that the use of a calculator improved overall drug calculation outcomes while others found that there was no significant difference when a calculator was used for drug calculations. In order to have a better understanding of the effect of calculator use on drug calculation performance, this research investigated the relationship between calculator use and drug calculation outcomes and conceptualization, as well as the relationship between calculator use on anxiety and self-efficacy related to drug calculations.

Strategies need to be found that will help nursing students preparing to write the drug calculation test, to decrease their anxiety, increase their self-efficacy and improve medication administration conceptualization and drug computation outcomes. In addition, the effect of using calculators in nursing drug calculation tests has been varied and its effect on math test anxiety or self-efficacy about math has not been explored. These gaps in the literature therefore warrant further research in these areas. My study contributes to the literature by including a questionnaire to collect data on the effect of calculator use on the dependent variables of student anxiety, and self-efficacy, related to drug calculations.

CHAPTER FOUR
METHODOLOGY

4.1 Setting and Research Context

At John Abbott College (JAC) there are three nursing programs offered in Continuing Education and one offered in the day division. The day division nursing program is a three-year program that prepares students both for immediate entry into the profession as well as for continuation of their studies at the university level. Students complete nursing courses as well as courses related to concepts necessary for nursing practice. Students all take courses that lead to a more general education. The participants in this research will be from the day division nursing program.

There are approximately 100 students who register for nursing day division program in the first semester and 60 to 70 students who graduate annually. Students come to the John Abbott College nursing program from diverse cultural and educational backgrounds and their numeracy skills are varied. As aforementioned, some have not worked with fractions or decimals for a number of years or have grown accustomed to using calculators to solve math problems. Although students are predominantly female (98%), there are a few male students in each cohort. The majority of the students come directly from high school but there is a significant number who are returning to school after having pursued other interests.

4.2 Study Participants

The sample for this study included approximately 74 second year and 55 third year nursing students (N=129) enrolled in the day division nursing program at John Abbott College in Fall 2017.

4.3 Sampling

Convenience sampling was used for this research, as the students in the JAC nursing program were easily accessible. Students from 2nd and 3rd year were asked to participate in the research. First year students were excluded, as this research was not supported pedagogically in the JAC nursing program for first year students.

4.4 Research Design

In this study there was one independent variable (IV) - the use of the calculator. There were also four continuous dependent variables (DV) - DV_1 arithmetic skills, DV_2 conceptualization skills, DV_3 self-efficacy and DV_4 anxiety. A quasi-experimental design was used. The participants were not randomly selected, but a convenience sample was taken of students enrolled in the second and third years of the JAC nursing program in Fall 2017.

4.5 Data Collection Procedures

The winter 2017 semester was the first time that the second and third year nursing students were allowed to use calculators during the drug calculation test called a "Medication Administration Quiz" (MAQ) at John Abbott College. The first year students however, were still required to take this quiz without using calculators. A practice medication administration quiz (PMAQ) was administered in the third week of the semester for second and third year students, before they wrote their actual MAQ in week four, which counts towards their final grade. The students already received instruction in weeks one and two; on the type of drug calculations they will be expected to perform in their respective semesters. The PMAQ consisted of two versions. Each version of the PMAQ was randomly distributed to the participants, so that approximately half of the students started with version A and finished with version B, and the other half began with version B and ended with version A. This was to compensate for any overlooked differences in the two versions of the PMAQ. Half the participants completed the first version received without a calculator and the second version received with a calculator. The other half of the participants started with a calculator and ended without a calculator. This was to nullify any effects of having started with the calculator. Students were required to submit the first version before they were given the second version.

Following the completion of both versions of the PMAQ, students anonymously and electronically completed the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) (See Appendix C). The MSEAQ used a 5-point Likert-type scale and consisted of 18 questions related to their self-efficacy and their anxiety

about drug calculations in general and also about their self-efficacy and their anxiety when performing drug calculations with or without a calculator. Questions related to students' familiarity with calculators and math backgrounds were also included. The PMAQ lasted a total of 40 minutes with the first and second parts having a duration of 20 minutes each. An additional 20 minutes was allotted for the completion of the MSEAQ.

Students in 3rd year switched clinical rotations halfway through the semester and took another MAQ corresponding to the new clinical rotation. The PMAQ was therefore repeated for the 3rd year students in week 10, one week before they took their second MAQ. This was to ensure equality of preparation for all the students for each MAQ. Students were given the opportunity to review their PMAQ with their clinical teacher and to seek remediation if needed before they took each of the MAQs that counts toward their final grade.

4.6 Analysis

Versions A and B were analyzed for computation errors by looking at the number of questions answered correctly as well as the number arithmetic errors made e.g. addition, subtraction, multiplication and division. They were also analyzed for conceptualization errors such as errors in setting up the problem e.g. setting up the problem as a division when it should be a multiplication or using the wrong set of values for the computation; applying the wrong unit of measure, rounding off and concept not understood. The category "concept not understood" was used when the calculation did not make sense, was incomplete or not attempted. A t-test was used to analyze the relationship between calculator use and both computation errors, and conceptualization errors by first computing the mean and standard deviation for each variable. Tests for significance determine the probability that the results are due to an error in sampling.

The responses from the MSEAQ were divided into two broad sections. Section one consisted of general questions related to their math background and familiarity with calculators. The responses to these questions were analyzed using percentages and this information was included with the demographic data. Section two questions

were further divided into two segments for analysis namely, general questions related to their anxiety and self-efficacy with drug calculations, and questions comparing their anxiety or self-efficacy with drug calculations to the use of a calculator or to no calculator use. The percentages for each response choice were calculated for all the questions and a chi-square test for significance performed. A chi-square test for significance is used to analyze categorical variables (Beau dry & Miller, 2016). Although anxiety and self-efficacy are continuous variables, due to the design of the research and the structure of the survey questions (both the dependent and independent variable was stated in the question) they were treated as categorical variables.

Although MAQ data collected for students in 2nd and 3rd year were analyzed separately, the results were compared and discussed as a whole, highlighting any outstanding differences. The MSEAQ results were analyzed with the 2nd and 3rd year group being considered as one cohort due to a limitation in the design of the research.

4.7 Instruments

The MSEAQ was originally developed to look at the relationship between mathematics self-efficacy and mathematics anxiety (May, 2009). The final version of this questionnaire was developed with input from teachers and students on a trial version. The reliability and validity of the questionnaire was determined by using an exploratory factor analysis design. It consisted of 29 items that were rated using a 5-point Likert-type scale (1 = never, 2 = seldom, 3 = sometimes, 4 = often and 5= usually). Only 28 items were used in the analysis, as one item was not functioning as expected. The 28-item questionnaire has a Cronbach alpha of .94 indicating a good internal reliability. The MSEAQ results were comparable to those of other established mathematics self-efficacy and mathematics anxiety questionnaires.

The MSEAQ was adapted for this study by changing the word “mathematics” to “drug calculation” and by adding “with a calculator” or “without a calculator” to a few items. (See Appendix C) The number of items in the questionnaire was also reduced to 18, as some of the items did not address the research questions in this study. Using the 5-point Likert-type scale described above, and separating the self-

efficacy questions from the anxiety questions, the percentages of each response was calculated to determine higher levels of anxiety and self-efficacy in general. A chi-square test of significance was performed to identify how these characteristics are related to calculator use in drug calculations. General questions related to the participants' math background and familiarity with calculator use were added to the questionnaire. Permission to adapt and use the MSEAQ was granted by Diana K May, now Swanagan, on May 3rd 2017 via email (See Appendix C). However, these modifications to the questionnaire means that the reliability and validity would also need to be re-evaluated which is not feasible for this project.

The PMAQ was developed using questions from the previous year's MAQ used in the second and third year Fall semesters of the JAC nursing program. The dosages in the doctor's orders and/or the medication available and/ or the drug names in the questions were changed to create PMAQ version A and version B. Teachers in the respective semesters vetted both versions for the level of conceptualization and computation skills appropriate for the semester and clinical rotation of the student as well as the equality of the two versions.

4.8 Trial Study

A trial run of this research was performed at the beginning of June 2017 to test the instruments developed for this research, to verify the time needed to complete the PMAQ and the questionnaire, and to explore the best way to analyze the data. Fifteen students in their third year of the intensive nursing program at John Abbott College completed the PMAQ and responded to the questionnaire. Some students were three times faster at completing the PMAQ with a calculator while the majority took between 12 and 15 minutes. Only one student took the full 20 minutes to complete the PMAQ with a calculator. All students took the full 20 minutes to complete the PMAQ without a calculator. The results of the PMAQ were analyzed using a t-test. The pilot showed that Arithmetic errors were more likely without a calculator than when a calculator was used for drug calculations. This was an expected finding as Shockley et al. (1989) already demonstrated this in her study. No arithmetic errors were made with the use of a calculator. In addition, there was no difference in

conceptual errors with or without the use of a calculator for drug calculations. This is different to the result obtained by Shockley et al. (1989) where they found that the use of a calculator negatively impacted conceptual outcomes.

Some of the conceptualization difficulties that emerged from these pilot findings were:

- Using the incorrect values to solve the drug calculation
- Applying the wrong units of measure to the answer
- Rounding off when the dose should be left to two decimal places
- Failure to determine if the answer made sense given the context of the drug calculation.

These difficulties were similar to those found in previous studies investigating nursing students' drug calculation abilities. One such study reported that nursing students had difficulty with basic math skills and that they were unable to use them accurately for drug calculation and administration (Bagnasco et al., 2016).

This pilot demonstrated that the time set for the PMAQ was adequate for the number of questions to be completed without a calculator. Students had more time than was needed to complete the test with a calculator. The time was not altered, as it was reflective of the time given for their actual MAQ. The analysis for the PMAQ was also suitable for the study. The analysis for the MSEAQ was not completed in the pilot study, as the originally planned correlational analysis did not fit with the design of the project. Subsequently the method of analysis of the MSEAQ was changed to a chi-square test.

4.9 Ethical Considerations

A research assistant was assigned to provide the study information, explain the study and conduct the consent process. A verbal explanation of the purpose of the study and the potential benefits to the students as well as the nursing department was given (Appendix D). A complete explanation of what participation in this study entailed was given, questions were answered and discussion was permitted so that participants were able to give informed consent (Appendix E). Students were assured that strict confidentiality would be observed. Witten information summarizing the

value of this research to patient care was given to the students (Appendix F). All practice MAQs; questionnaires and data collected from these instruments were coded numerically to protect participant anonymity. Students were informed that if they chose to withdraw from participation at a later date, all data of any kind related to the student would be erased and/or destroyed and that they could withdraw at anytime. They were assured that these results would not affect their overall grade in the nursing course.

Students who participated in this study took a practice Medication Administration Quiz (MAQ) that did not count for marks. It was held outside of class time during a common free period. The PMAQ consisted of two versions of the drug calculation quiz. Some students completed the first version received with a calculator and the second version received without a calculator. The other students started without a calculator and finished with a calculator. Each version was 20 minutes long. At the end of the second version of the PMAQ received, students completed the MSEAQ online using their own devices. For those who did not have a device with which they could connect to the Internet, one was discreetly provided. They had 20 minutes to complete the questionnaire. Those who did not wish to participate had the option to stay and wait out the 20 minutes or they could leave the room when at least one student had completed the MSEAQ. This maintained their confidentiality with regard to participation. There were no anticipated risks to the participants however, students benefited by having an opportunity to practice for their actual MAQ and to seek remediation if necessary before taking the required MAQ which counts towards their final grade.

All data will be securely stored for a minimum of two years. Subsequent to this, all completed questionnaires will be shredded, and electronic data will be deleted. A summary of this proposal was submitted to the John Abbott College Ethics Committee on May 11th 2017 and approval was granted on May 24th 2017. A copy of the application and the approval is included in appendix F and G respectively.

4.10 Research Schedule

Date	**Phase of research**
May 11th	Summary of proposal submitted to Ethics committee
May 24th	Ethics approval received
June- October	Finalizing proposal for marking by teachers
August 15th	Print Consent forms and tools for Data collection
August 21st	Research project presented to 2nd and 3rd year students and consent obtained
September 5th	Data collection from 3rd year students first rotation
September 6th	Data collection from 2nd year students
October 24th	Data collection from 3rd year students second rotation
November 4th	Submit proposal for marking
November 10th	Submit proposal to U of S
November	Begin data analysis (identification of types of errors and tallying arithmetic errors and conceptual errors) Meet with Richard Masters for guidance with performing t-test and Chi-square test.
December	Input data into excel spread sheet for further analysis
January 2018	Perform t-test on data from PMAQ
February 2018	Perform Chi-square test on data from MSEAQ
March and June 2018	Completion of Thesis

CHAPTER FIVE

RESULTS

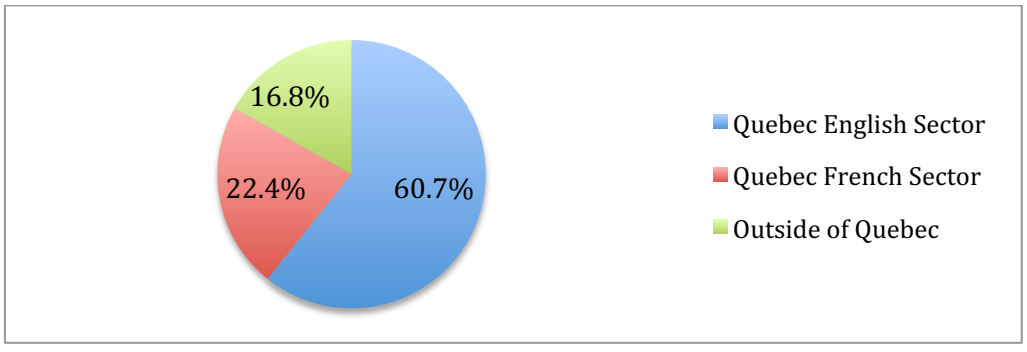
This study explored the relationship between calculator use and the responses of John Abbott College nursing students to questions on a practice medication administration quiz. Specifically, it sought to replicate previously found results - that calculator use was associated with fewer arithmetic errors and more conceptual errors on drug calculation problems (Shockley, McGurn, Gunning, Graveley & Tillotson, 1989). In addition, this study endeavored to determine if calculator use is related to student self-efficacy and anxiety as it pertains to drug calculations.

5.1 Participants

Students who enroll in the JAC nursing program come from varying backgrounds. Nursing is still a predominately female discipline but there were however a few men enrolled in each cohort invited to participate in this research. The gender distribution of the participants was not surveyed to preserve the anonymity of the participants. Most of the participants (n = 104) indicated that they were very comfortable using a calculator however 4 participants were somewhat uncomfortable using a calculator. Most of respondents studied Mathematics in Quebec while 16.8% of respondents studied outside of Quebec (Figure 3). Although the highest level of Mathematics taken for most students was at the High School level, 10 students took Mathematics at the university level.

Figure 3

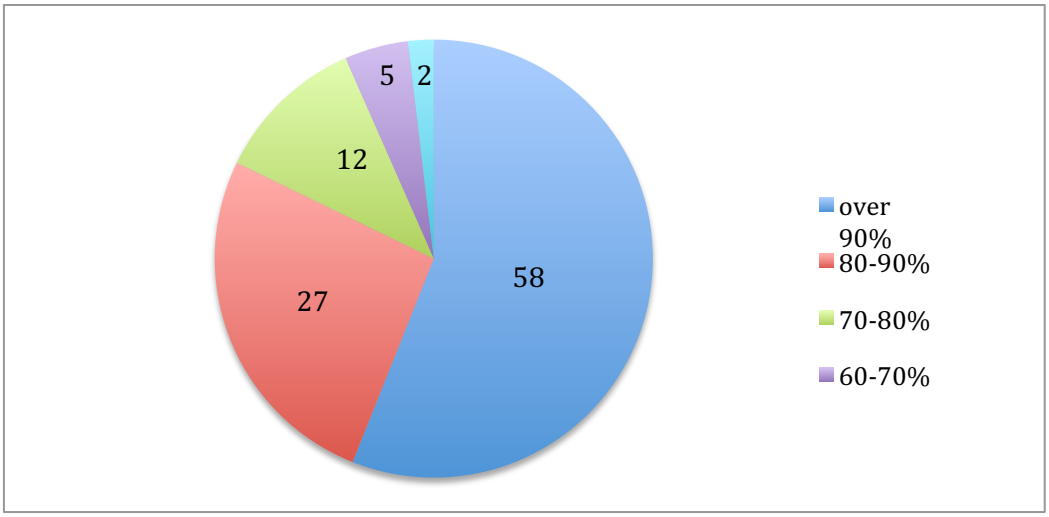
Distribution of where respondents completed High School Mathematics.



Participants were surveyed for their drug calculation ability on their previous semesters MAQ. 82.3% of the participants (n = 104) were able to obtain 80% or more on their first attempt of the previous semester's MAQ (Figure 4).

Figure 4

Distribution of respondents' grades on previous semester's MAQ.



In an attempt to get a better understanding of how students approach solving drug calculations, three questions were included on the survey to address this. The responses indicated that 38.3% of the respondents (n = 104) sometimes estimated what the answer would be before solving the problem but 23.4% never did. After the calculation was complete 65% usually thought about whether their answers made sense. When asked about strategies they find helpful to solve the drug calculations, 59.8% of the respondents said that they used a formula. Visualization was used by 16.3% of the students. Other helpful strategies used were highlighting important data, being conscious of the steps to take, drawing, reading the question carefully and using a calculator.

Out of a total of 129 students enrolled in the second and third year of the Fall 2017 JAC nursing program, 104 voluntarily participated in this research project. Fifty-six second year students took the PMAQ and MSEAQ. A total of 48 3rd year students participated in this research. Of these 48 students, 42 participated during their pediatric rotation and 38 participated during their surgical rotation. The PMAQ

for two clinical groups, a total of 12-second year nursing student MAQ responses were not returned to the researcher. However, their responses on the MSEAQ were recorded and included in the analysis. Some students did not respond to all the questions on the MSEAQ. The omitted questions were removed from the analysis. Some students also omitted to include the time taken on their MAQ. When the time was being analyzed these MAQs were omitted from the analysis. There were challenges with the internet connection and three students had to start over the MSEAQ, which resulted in the duplication of some of their MSEAQ answers. When responses were duplicated only one answer was used during the analysis.

5.2 Arithmetic Errors

H_1: Drug calculation arithmetic outcomes are different for students who use a calculator than for students who do not use a calculator.

The variables used to determine the effect of calculator use on Arithmetic outcomes of drug calculations were their grades on a PMAQ, time to complete the PMAQ and errors in performing addition, subtraction, long division, division of decimals, and multiplication on the PMAQ. A t-test of significance was carried out on the results obtained from the PMAQ. The scores on these variables consistently demonstrated that when a calculator was used there was a significant difference in drug calculation outcomes. Students took less time to complete the drug calculations (Figure 5), scored higher on the MAQ when using a calculator (Figure 6) and made fewer errors in long division (Figure 7). The pediatric group also made fewer multiplication errors when using a calculator.

When considering the time taken to complete the drug calculation quizzes, the 2^{nd} year nursing students took an average of 17.6 minutes out of 20 without a calculator and 16.0 minutes out of 20 with a calculator (Figure 5). Although the difference in time taken was small, a t-test showed that there was a significant difference in the time taken to complete each quiz of the PMAQ (Table 1). Similarly for the pediatric group, the average time taken to complete the quiz without a calculator was 18.3 minutes and with a calculator the time taken was 12.1 minutes (Figure 5). Using a t-test demonstrated that the time taken to complete each quiz was

significantly different. These results were repeated for the surgical group. The average time taken to complete the quiz without a calculator was 17.7 minutes and with the calculator it was 11.8 minutes. Again a significant difference in time was shown when a calculator was used (Figure 5 and Table 1). The time taken was not recorded for all the participants and this affected the degree of freedom used to calculate the significance.

Figure 5

Comparison of time taken to complete medication administration quizzes without the use of a calculator and with the use of a calculator for 2nd year, pediatric and surgery cohorts.

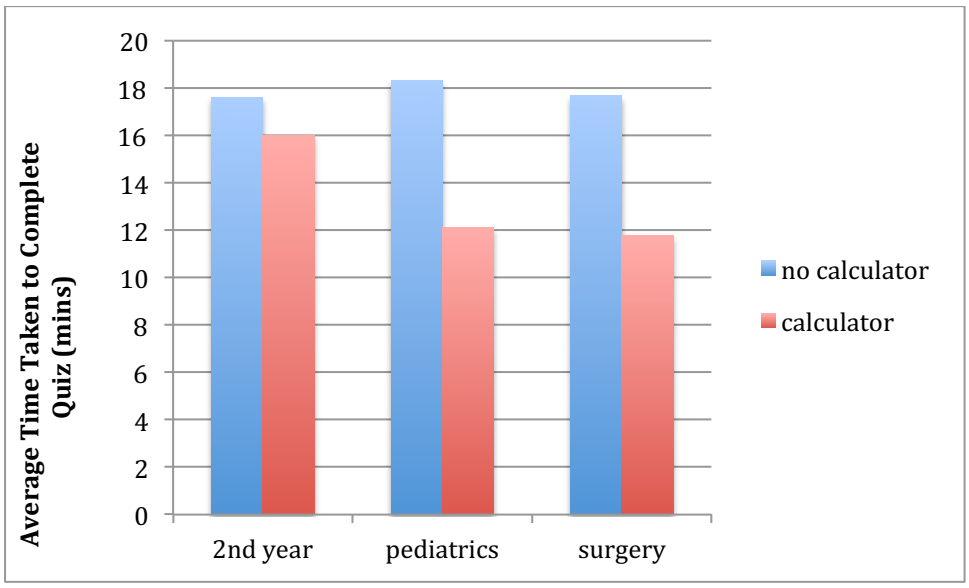


Table 1

Mean, variance and critical values of a t-test on time to complete medication administration quiz without the use of a calculator and with the use of a calculator.

Variable	2nd year		Surgery		Pediatrics	
	Mean	Variance	Mean	Variance	Mean	Variance
No calculator	17.6	7.6	18.3	6.0	17.7	13.2
Calculator	16.0	4.3	12.1	6.6	11.8	28.7
	t(42)=2.0*		t(39)=2.0*		t(36)=2.0*	

*p ≤ .05 for each cohort

Grades on the drug calculation quizzes were higher when a calculator was used. The second year nursing students had an average grade of 4.9/8 without the use of a calculator and an average grade of 6/8 when a calculator was used. The pediatric group scored an average of 2/5 without a calculator and 4/5 with the use of a calculator. The surgical group also performed better with the use of a calculator scoring 3.3/5 and 2.6/5 without the use of a calculator (Figure 6). A t-test of significance indicated that there was a significant difference in the grade when a calculator was used for each of these cohorts (Table 2).

Figure 6

Comparison of grade on medication administration quizzes without the use of a calculator and with the use of a calculator for 2nd year, pediatric and surgery cohorts.

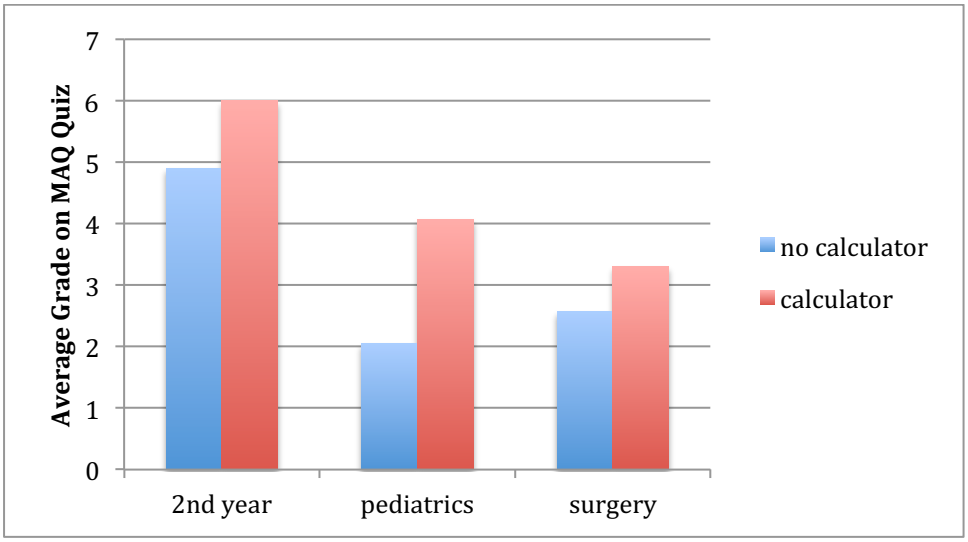


Table 2

Mean, variance and critical values of a t-test analysis on medication administration quiz grades without the use of a calculator and with the use of a calculator.

Variable	2nd year		Surgery		Pediatrics	
	Mean	Variance	Mean	Variance	Mean	Variance
No calculator	4.9	2.3	2.0	1.9	2.6	1.5
Calculator	6.0	2.5	4.1	1.0	3.3	1.4
	t(42)=2.0*		t(42)=2.0*		t(36)=2.0*	

*p ≤ .05 for each cohort

There was a significant difference in the number of long division errors made when a calculator was used. The second year students made an average of 0.5 long division errors without a calculator and an average of 0.02 errors with a calculator. The pediatric group made the most long division errors of all the cohorts with an average of 1 error without the calculator and 0.09 with the calculator. The 3rd year surgical group made the least long division errors without a calculator (0.3) and 0.05 errors with the calculator. A t-test of significance indicated that there was a significant difference in the long division errors made when a calculator was used for each of these cohorts (Figure 7 and Table 3).

Figure 7

Comparison of division errors on medication administration quizzes without the use of a calculator and with the use of a calculator for 2nd year, pediatric and surgery cohorts.

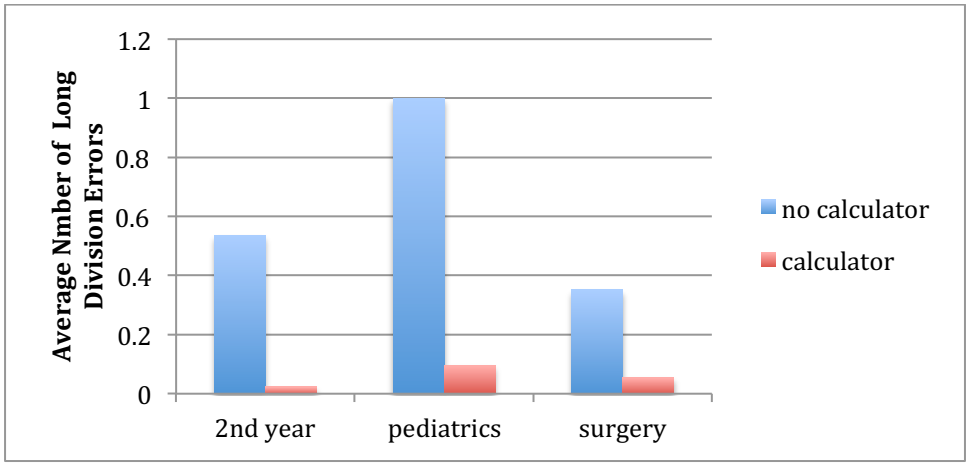


Table 3

Mean, variance and critical values of a t-test analysis on medication administration quiz long division errors without the use of a calculator and with the use of a calculator.

Variable	2nd year		Surgery		Pediatrics	
	Mean	Variance	Mean	Variance	Mean	Variance
No calculator	0.5	0.5	1.0	0.5	0.4	0.1
Calculator	0.0	0.0	0.1	0.1	0.3	0.1
	t(42)=2.0*		t(42)=2.0*		t(36)=2.0*	

*p ≤ .05 for each cohort

5.3 Conceptual Errors

H_2: Drug calculation conceptualization skills are different for students who use a calculator than for students who do not use a calculator.

The variables used to determine the effect of calculator use on conceptualization skills were errors in rounding off, wrong numbers chosen for the calculation, applying the wrong units of measure, and concept not understood. "Concept not understood" was used when the error made did not fit into one of the chosen variables or when the type of error made could not be identified. The conceptual variables used were chosen from the results of a pilot project ran in January 2017 with the intensive nursing students at JAC.

The participants did not make any errors in applying the units of measure to the drug calculation, so it was eliminated from the analysis. A significant difference when a calculator was used was shown only in the variable "concept not understood" and only in the cohorts of the 2nd year nursing students and the 3rd year pediatric group (Figure 8 and Table 4).

Figure 8

Comparison of concept not understood errors on medication administration quizzes without the use of a calculator and with the use of a calculator for 2nd year, pediatric and surgery cohorts.

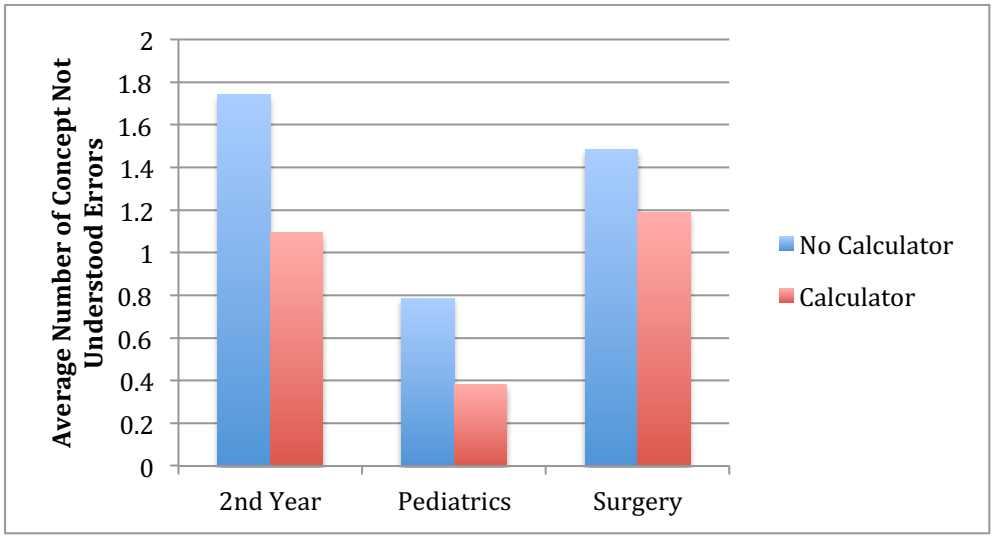


Table 4

Mean, variance and critical values of a t-test analysis on medication administration quiz concept not understood errors without the use of a calculator and with the use of a calculator.

Variable	2nd year		Surgery		Pediatrics	
	Mean	Variance	Mean	Variance	Mean	Variance
No calculator	1.7	2.0	0.8	0.8	1.5	1.3
Calculator	1.1	1.1	0.4	0.5	1.2	1.4
	t(42)=2.0*		t(39)=2.0*		t(36)=2.0*	

*$p \leq .05$ for each cohort

5.4 Self-Efficacy and Anxiety

H_3 and H_4: The level of math self-efficacy and math test anxiety is different for students who use a calculator than for students who do not use a calculator.

5.4.1 Self-efficacy and anxiety related to drug calculations. In general, most participants were confident that they could understand the content related to drug calculations when it was taught however 61.6% reported feeling stressed during these classes. Most were either confident or somewhat confident to ask questions. Only 43% were confident when taking drug calculation tests but 88.8% were anxious about not doing well on the test. Interestingly, 75.9% believed that they could get the required 80% to pass. 55.6% of the participants were confident that they would be able to perform the drug calculations when they are nurses.

5.4.2 Self-efficacy and anxiety related drug calculations when a calculator is used. Participant responses indicated that 83% were more confident and 81% were less anxious when performing drug calculations with a calculator. 85% believed that they could achieve a passing grade and 59.5% were less worried about getting a passing grade when they performed a drug calculation test using a calculator. 67.3% of the students were less confident and 42% were more worried about their future success performing drug calculations when they could not use a calculator. 67.3% of the participants responded that they were less confident and 51.9% were more worried that they will not be able to perform drug calculations in the clinical setting if they could not use a calculator. A Chi-square test confirmed the significance of the

responses when questions about self-efficacy with the use of a calculator to complete drug calculations was compared to self-efficacy without the use of a calculator to complete drug calculations (Table 5). Significance was not shown in two of the comparisons when responses to questions about anxiety with the use of calculator to complete drug calculations was compared to anxiety without the use of a calculator to complete drug calculations (Table 6). .

Table 5

Chi-square, degree of freedom and significance of respondents' self-efficacy when a calculator is not used for drug calculations and when a calculator is used for drug calculations.

Variable	No Calculator	Calculator	Chi-Square	df
	12. I feel I will do better in future drug calculation tests when I cannot use a calculator	11. I feel more confident when performing drug calculations with a calculator	31.1	12
Self-efficacy	12. I feel I will do better in future drug calculation tests when I cannot use a calculator	13. I feel more confident I can get 80% on a drug calculation test with a calculator	28.3	12
	14. Without the use of a calculator I feel I will do better on drug calculations in the clinical setting	11. I feel more confident when performing drug calculations with a calculator	45.8	12
	14. Without the use of a calculator I feel I will do better on drug calculations in the clinical setting	13. I feel more confident I can get 80% on a drug calculation test with a calculator	21.8	12

Table 6

Chi-square, degree of freedom and significance of respondents' anxiety when a calculator is not used for drug calculations and when a calculator is used for drug calculations.

Variable	No Calculator	Calculator	Chi-Square	df	p-value
	16. I worry more that I will not do well in future drug calculation tests when I cannot use a calculator	15. I worry more when performing drug calculations with a calculator	21.8	12	*0.0
Anxiety	16. I worry more that I will not do well in future drug calculation tests when I cannot use a calculator	17. I worry less about getting 80% on a drug calculation test with a calculator	27.7	16	*0.0
	18. Without a calculator I worry less that I will be able to carryout drug calculations in the clinical setting	17. I worry less about getting 80% on a drug calculation test with a calculator	19.9	16	0.2
	18. Without a calculator I worry less that I will be able to carryout drug calculations in the clinical setting	15. I worry more when performing drug calculations with a calculator	12.9	12	0.4

*$p \leq .05$

5.5 Other Findings

Drug calculation tests highlight areas of difficulty for nursing students (Grugnetti, Bagnasco, Rosa & Sasso, 2014) and a few areas were highlighted in this research. Students in the 2nd and 3rd year of the nursing program made more errors when the drug calculations involved the calculation of intravenous rates. The 2nd year students also made significant amounts of errors in calculations requiring the use of an insulin sliding scale where as the 3rd year surgical students made more errors with drug calculations related to heparin rates.

CHAPTER SIX
DISCUSSION

6.1 Arithmetic Errors

The literature on the effect of using a calculator on drug calculation outcomes was inconsistent. One study found that there was no difference in grades when a calculator was used (Tarnow et. al., 2000), however in another study, calculators were associated with fewer arithmetic errors (Shockley et al., 1989) and higher scores (Murphy & Graveley, 1990). The results of this study corroborate the findings by Shockley et al., that is, that calculators were associated with fewer arithmetic errors.

The time taken to complete the PMAQ was shorter when a calculator was used. Although the literature did not report on the effect of calculator use on the time to complete the drug calculations, it was expected that less time will be taken with a calculator, as the pilot study performed in June 2017 showed that students were between five to seven minutes faster when using a calculator.

Students had significantly less errors with division when a calculator was used. This is consistent with the literature, as teachers found that division was a challenge for nursing students at all levels (Mackie & Bruce, 2016).

Interestingly the pediatric group showed a significant improvement in multiplication when using a calculator that was not evident in the other cohorts. The drug calculations used in pediatrics require several multiplication steps including whole numbers as well as decimals. This perhaps presented more opportunities for multiplication errors to be made and why the use of the calculator mitigated some of these mistakes.

6.2 Conceptual Errors

The literature was inconclusive about the effect of calculator use on conceptual errors. Conceptualization includes being able to visualize the problem, to choose the correct information to use to solve the problem as well as setting up the calculation accurately. Shockley et al., (1989) reported an increase in conceptual errors when a calculator was used for drug calculations whereas Murphy & Graveley, (1990) reported that students made fewer errors in setting up the drug calculation when using

a calculator. The results of this research indicated that there was no difference in conceptual errors with or without the use of a calculator except in the variable "concept not understood". This difference was unexpected and occurred only with the 2nd year and pediatric group of students. There could be several reasons for the difference found in this variable.

The 2nd year nursing students were newly introduced to the drug calculations required for surgery. Similarly the 3rd year students in the pediatric rotation learned the specifics for pediatric drug calculations at the beginning of the semester. They may have been more anxious about the test and have less confidence about their drug calculation abilities. Test anxiety uses up the working memory during the test making it unavailable for use to solve test questions (Paas & Ayres, 2014). Researchers have also found that there exists a direct relationship between a student's math self-efficacy and their performance on math tests (McMullan et al., 2012). The 3rd year surgical students already had practice with drug calculations specific to surgery and may have also been less anxious and more confident about their understanding of the drug calculation problems.

The variable "concept not understood" included several different types of errors such as not setting up the problem correctly, not attempting the question, an incomplete response or not finishing a question and any other errors that did not fit the three variables being used to test conceptual errors. This increased the opportunity for an error to be categorized as "concept not understood" and may be responsible for the increased number of errors in this variable category. Students may not have attempted or completed a question because of difficulty deducing, reasoning or understanding the concepts. Since these are complex math skills that a calculator cannot perform (Bagnasco et al., 2016) then perhaps the improvement shown when a calculator is used is related to its effect on the student's anxiety and self-efficacy.

6.3 Self-Efficacy and Anxiety in general toward drug calculations

The test anxiety of the participants of this study was higher than expected at 88.8%. According to the literature some students reported experiencing anxiety related to the high level of accuracy expected in the drug calculation test (Walsh,

2008). In the drug calculation test at JAC, students must achieve 80% to pass. 75.9% of the respondents believed that they could get this required passing grade. This leads to a second possibility for the anxiety result obtained. Not all anxiety is negative anxiety (Roykenes, 2016). Some students experience anxiety because they want to demonstrate what they know (Roykenes, 2016). It is possible that some students who indicated that they felt anxious about not doing well on the test fit into the second reason for their test anxiety. From the demographic results, 85% of the participants passed their previous MAQ. This further suggests that the self-efficacy of these students would be high as past performance on similar tests influences one's feeling of confidence on future similar tests (Roykenes, 2016).

6.4 Effect of the Calculator on Self-Efficacy and Anxiety

Overall students indicated that their self-efficacy was higher when they used a calculator (83% felt more confident and 85% believed that they could get a passing grade when a calculator was used). The MAQ results also showed that the participants received higher grades, made less long division errors and less conceptual errors when a calculator was used. This is supported by the literature, which indicates that there is a direct relationship between a student's math self-efficacy and their performance on math tests (McMullan et al., 2012). Since their self-efficacy was higher when they used a calculator students performed better on drug calculations.

Anxiety was also improved when a calculator was used with 81% of the respondents indicating that they were less anxious when performing drug calculations with a calculator. Anxiety is inversely related to self-efficacy (McMullan et al., 2012), so it makes sense that the respondents will also be reporting decreased anxiety with the use of a calculator. However, this decrease in anxiety was not significant. This is probably because a certain level of anxiety positively affects performance outcomes and is present regardless of one's preparedness for the test (Rana & Mahmood, 2010).

That participants performed better on drug calculation outcomes when a calculator was used is related to its effect on their self-efficacy and anxiety as well as its function in improving the accuracy of their arithmetic skills.

6.5 Other findings

Many studies indicated that errors in intravenous medication administration occur frequently - between 13% and 84% (Pauly-O'Neill, 2009). One explanation for these errors with the JAC students is the lack of practice. The MAQ is usually administered before the students begin medication administration in the clinical setting. Once medication administration has begun for the rotation, many students only get one or two opportunities to practice this skill. It may be challenging for some students to conceptualize the preparation and administration of medication without having performed the skill, therefore making it difficult for them to be successful on the MAQ. One of the skills necessary to safely prepare and administer medication is the ability to visualize the procedure, dosage and units of measure for the medication calculation (Grugnetti et al., 2014). A similar argument could be made for heparin and using the sliding scale. Students at JAC are usually given practice questions and a tutorial to help them prepare for the MAQ. They are also encouraged to seek extra help from them teachers if needed.

Preparing pediatric medication requires multiple calculations and thus multiple opportunities for error (Pauly-O'Neill, 2009). In the pediatric group many students had difficulty differentiating between an unsafe dose and a dose that was sub therapeutic. They also confused mg/day and mg/dose. The concepts of safe verses sub therapeutic is applied in the pediatric rotation as the dosages are calculated based on the patients weight and this is a new concept for the students. The students were also tested at the beginning of their rotation when their exposure to the practical aspects of these concepts was limited. These could account for the number of errors seen in this category.

6.6 Recommendations

Based on the results, it would be important for teachers to offer students the opportunity to practice drug calculations in a simulated environment to complement

their exposure in the clinical setting. Clinical simulations that are well designed so that they are realistic and include distractions can help students visualize the medication dose to be administered and improve the accuracy of drug calculations (Pauly-O'Neill, 2009). At JAC a simulation lab already exists so incorporating more drug calculations into the simulation labs would be quite feasible.

Similarly, medication preparation (which include drug calculations) and administration should be tested only after some clinical or simulation experience with this skill has been gained so that students can be more successful on the MAQ. Perhaps testing of drug calculation abilities should also include visual cues as used in simulation and the manipulation of the medication.

Since the JAC nursing students demonstrated difficulty with calculations involving IV's, insulin sliding scales and heparin rates, it would be important for teachers to incorporate more opportunities for students to practice these types of calculations. In the pediatric rotation more opportunities to differentiate between the concepts of safe doses and therapeutic dosages should be provided.

As this research demonstrated that the use of a calculator improved drug calculation outcomes for the JAC nursing students in second and third year, it is recommended that the use of calculators for drug calculations be extended to the first year students also.

6.7 Limitations and Future Research

The survey method was used to collect data regarding student's self-efficacy and anxiety related to drug calculations. Although this was a valuable tool for this research, adding interviews from a focus group would add more depth to the results and give a better understanding of the difficulties students were having with drug calculations particularly in the area of conceptualization.

The MSEAQ questionnaire was administered once at the end of the PMAQ. Perhaps administering the survey after each version of the drug calculation quiz would help students to more accurately report their feelings about the use of a calculator for drug calculations. The results of the two surveys could then be compared using a correlational analysis to determine the relationship between

calculator use for drug calculation outcomes and self-efficacy and anxiety related to drug calculations. A correlational analysis could not be used in the current design as the independent variable (calculator) and dependent variables (self-efficacy or anxiety) were embedded in the survey question. This made it difficult to test their relationship. Rewording the MSEAQ questions so that they were clearer would also improve the quality of this research.

Students in the 3rd year surgical rotation had more experience with drug calculations related to surgery as they also had a surgical rotation in their 2nd year. It was the first exposure for students in the pediatric rotation. This predisposed the pediatric cohort to making more errors.

This research used participants from the John Abbott Nursing program only. To get a better understanding of the drug calculation challenges in the Colleges of Quebec, students from the other colleges, including the French Colleges should be invited to participate. This would ensure transferability of the results of this type of research.

It would also be interesting to expand this research to investigate how drug calculations are approached in the different nursing programs of Quebec and determine which teaching modalities are having the most success. Teacher interviews could be used to obtain information on the teaching method used and student's grades on an MAQ could be used to determine the success of the teaching method. Students could also be interviewed to find out their perceptions on what would make the teaching method better. This could possibly lead to the development of a model for teaching drug calculations that results in an increase in drug calculation accuracy and enhanced patient safety.

6.8 Conclusion

The use of a calculator for drug calculations improved overall drug calculation outcomes. The time taken to perform the drug calculations, the grade and the arithmetic outcomes of long division and multiplication were better when a calculator was used. This was similar to the findings of Shockley et al. (1989) who found that calculator use increased computation accuracy. However, for students who had

difficulty conceptualizing the problem, no relationship to calculator use was found. This was different from Shockley et al. (1989) who found that there was a decrease in conceptual ability when a calculator was used. Additionally, this study found that using the calculator had a positive relationship with student's self-efficacy. According to Bandura's self-efficacy theory this will lead to better performance outcomes on drug calculations (Figure 2). Although students reported feeling less anxious when using a calculator to perform drug calculations when compared to not using a calculator for drug calculations, no significant difference was shown. More research is needed to determine the relationship between calculator use for drug calculations and anxiety.

Improved drug calculation outcomes can only mean more accurate medication preparation and administration in the clinical setting. According to Cognitive load theory, when anxiety is decreased during drug calculation, working memory will be available for use to temporarily store the information immediately needed to solve the calculations (Figure 1). With improved self-efficacy, students are more likely to have better performance outcomes (Bandura, 1977). Improved drug calculations will have a direct improvement on patient safety.

Based on the results of this study i.e. that calculator use improved drug calculation outcomes, it is recommended that students in all semesters of the JAC nursing program be allowed to use calculators for drug calculations both in the classroom and in the clinical setting. This will not only improve their outcome on the MAQ and increase their self-efficacy related to drug calculations, but will improve patient safety.

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APPENDIX A

TABLE 1

Literature Matrix: Comparison of seven key articles

Author	RQ	Design and Methodology	Sample	Instruments	Results
Mackie, J. E. & Bruce, C. D. (2016) Research Education Today	1) Is there a problem with dose calculation abilities in the student nurse population at Trent/Flemming nursing school? 2) What types of error are the nursing students making? 3) Can a well-developed and targeted online intervention help to improve student performance on drug calculation tests?	Mixed methods study that started with a qualitative needs assessment and a quantitative assessment of types of errors made. Online remedial intervention implemented. Similar Qualitative and quantitative post intervention data collected a year later after the intervention.	For Quantitative part n=57 2nd year nursing students in 4 year nursing program For Qualitative: 8 students from year 1-3 in 4yr nursing program were interviewed 8 teachers involved in teaching drug calculations.	Online basic math skills and drug calculation modules. Pre and post intervention tests	From student interview: students found it challenging to estimate the answer, were unsure if the answer was correct, had difficulty with conceptualization and expressed low self-efficacy. Students noted that calculations became more difficult as they moved into a higher year of study and they had difficulty understanding how the calculations would be applied in practice. Teacher interviews: The most common challenge was long division evident across all student levels. Pre and posttests suggest that the students benefited from the online interventions.
McMullan, M., Jones, R., & Lea, S. (2012). Research In Nursing & Health.	1) The research questions were the following: What are the relationships between math anxiety, math and drug calculation self-efficacy,	A cross-sectional research design was used Half way through their second year of nursing students were	A convenience sample of all the second year undergraduate nursing students (n= 229) attending a British University	A drug calculation test A numerical ability test Math anxiety questionnaire	Most of the students who failed the numeracy test had math anxiety. Students who failed the numeracy test were less confident and

	numerical ability, and drug calculation ability? 2) Are there differences in the anxiety and self-efficacy levels between students who pass and those who fail numerical and/or drug calculation ability tests (DCAT)? 3) Which factors best predict drug calculation ability?	given two tests and three questionnaires to complete.		Math self-efficacy questionnaire Drug calculation self-efficacy questionnaire.	more anxious than those who passed. Most students who failed the drug calculation test had math anxiety. Students who failed the drug calculation test were more anxious and less confident in performing numeracy test.
Murphy, M. A., & Graveley, E. A. (1990) Nurse Educator	Does having the option to use a calculator: 1) Significantly affect performance of senior nurses when solving drug calculations 2) Significantly affect the number and types of errors 3) Overall exam performance	Repeated measures quasi-experimental design. Drug calculation tests were administered during the semester. 3rd year students were not allowed to use a calculator. 4th semester students had the option to use to use a calculator.	38 nursing students in their 3rd and 4th semester of a 4 semester accelerated baccalaureate nursing program	Drug calculation tests Calculator	1) Students with the option to use a calculator had higher Math scores and fewer set up and calculation errors. 2) No significant differences in overall exam scores when given the option to use a calculator.
Rana, R. A., & Mahmood, N. (2010). Bulletin Of Education & Research	Determine the relationship between academic achievement and 1) Test Anxiety total scale scores 2) Test Anxiety Emotional scale scores 3) Test Anxiety Worry scale scores	Qualitative research with descriptive analysis. Students were given a questionnaire to complete that consisted of affective and cognitive components of anxiety.	N=414 randomly selected postgraduate students from varying science departments.	Test anxiety inventory questionnaire (TAI).	A significant but strongly negative relationship exists between achievement scores and total anxiety scale sores. Achievement is negatively related to worry and emotional anxiety scales.
Røykenes, K., Smith, K., & Larsen, T.	How does the requirement for a flawless result on a drug	Mixed methods approach Quantitative (survey)	Quantitative: n= 205 freshman (first year) nursing	A questionnaire was created with items	The fact that students had to have a flawless result increased

M. (2014). Nurse Education in Practice.	calculation test affect nursing students' test anxiety?	followed by Qualitative (focus group interview) two years later. Participants in the focus group attended greater than 70% of a special education program.	students Qualitative: n=6 first year nursing students	from three pre-existing questionnaires on anxiety and self-efficacy. Education program for students with low mathematics self-concept or high text anxiety when faced with drug calculation test. An interview guide created by researchers	test anxiety. Worry thoughts was prevalent in this study while students prepared for the test as well as during the test. Text anxiety affected the students' expectations of the outcome of the test with students with high text anxiety expecting to fail the test.
Shockley, J., McGurn, W., Gunning, C., Graveley, E., & Tillotson, D. (1989). Journal of Nursing Education	To determine the effect of the use of calculators on the responses of undergraduate students to dosage calculations	Experimental repeated measures design A two-part drug calculation test completed with and without a calculator. First part without a calculator. Second part with a calculator. Passing grade 85%.	Undergraduate nursing students enrolled in the pharmacology course in Fall 1987 n=104 and spring 1988 n=62	Drug calculation test consisting of two similar parts. Calculator.	1) Calculator use was associated with fewer errors 2) Calculator use was associated with more conceptual errors 3) Previous arithmetic skills influenced arithmetic and conceptual skills independent of the calculator 4) No evidence to support improvement in overall performance was due to decreased anxiety related to of calculator use
Tarnow, Karen Gahan; Werst, Carrie L. (2000) Nurse Educator	To determine if student scores were significantly different when a calculator was used	One drug calculation test consisting of 2 similar parts distributed randomly. First test received completed with a calculator, final test completed without a calculator. Passing grade was 100%	First semester nursing students enrolled in a baccalaureate nursing school. N=85	Drug calculation test consisting of two similar parts. Calculator.	1) No significant difference in the number of passing scores was noted with or without the use of a calculator.

APPENDIX B
PRACTICE ADMINISTRATION QUIZZES

Exam Number_____

NURSING 180-30K

PRACTICE MEDICATION ADMINISTRATION QUIZ

(PART A)

INSTRUCTIONS:

PLEASE SHOW YOUR WORK.

1. Read and follow the directions for each question.

2. No additional paper will be allowed. When necessary, provide answers up to two (2) decimal points.

3. There are a total of 8 questions and 8 responses.

4. Your response must include all of the information required to completely answer the question.

5. Time allotted is 20 minutes.

6. When using a calculator you must still show how you set up the problem.

SECTION 1

Using the drug labels supplied, calculate the number of tablets required to administer one dose of the prescribed amount of the drug.

Supply: Prescribed:

Synthroid Tablets USP 0.05mg

1. Synthroid 25 mcg q.d

Answer:_____

Dilantin Tablets USP 100mg

2. Dilantin tablets 0.2g t.i.d

Answer:_____

SECTION 2

3. The physician has ordered the antibiotic Penicillin V Potassium 500 000units p.o. q.i.d. Using the label below, how many ml will you administer?

Answer: _____

SECTION 3

The doctor orders a complex IV therapy regimen.

IV infusion	Bag #1:	Lactaid Ringers 500 ml @ 110 ml/hr
Followed by:	Bag #2:	D5W/.45NS 1000ml @ 100 ml/hr
Followed by:	Bag #3:	NS 1000ml @ 75ml/hr

4. The first bag is to be started at 08:00 and run at 110 ml/hr.
   The drop factor is 15gtts per ml.
   The I.V. should be regulated at how many drops per minute?

Answer:_____

5. At 1800 hours, which I.V. solution is running and how much of that bag should the
   client have received?

Answer:_____

SECTION #4

Calculate the rate at which you will run the following IV orders.

6. 1000ml NS IV at 50ml/hr with a drop factor of 10gtts/ml

Answer:_____

SECTION 5

Mrs. Xavier has the following Insulin and sliding scale orders:

- Humulin R 18 units SC at 07h30, 11h30, and 17h30
- Humulin N 20 units SC at 07h30 and 21h30
- Humulin R SC as per sliding scale at 07h30, 11h30, 17h30, and 21h30.

Insulin Sliding Scale

Insulin Dose	Glucose Reading (mmol/L)
No coverage	Glucose ≤ 10.0
2 units	10.1 – 12.0
4 units	12.1 – 14.0
6 units	14.1 – 16.0
8 units	16.1 – 18.0
10 units	18.1 – 20.0
Hold insulin and Call MD stat	Glucose more than 20.1

7. At 07h30, Mrs. Xavier's blood glucose is 11.2 mmol/L. How much insulin should the nurse give now? Be specific.

Answer:_____

8. At 21h30, Mrs. Xavier's blood glucose is 17.3 mmol/L. How much insulin should the nurse give now? Be specific.

Answer:_____

END OF PART A

Exam Number_____

NURSING 180-30K

PRACTICE MEDICATION ADMINISTRATION QUIZ

(PART B)

INSTRUCTIONS:

PLEASE SHOW YOUR WORK.

1. Read and follow the directions for each question.

2. No additional paper will be allowed. When necessary, provide answers up to two (2) decimal points.

3. There are a total of 8 questions and 8 responses.

4. Your response must include all of the information required to completely answer the question.

5. Time allotted is 20 minutes.

6. When using a calculator you must still show how you set up the problem.

SECTION 1

Using the drug labels supplied, calculate the number of tablets required to administer one dose of the prescribed amount of the drug.

Supply: Prescribed:

Synthroid Tablets USP 0.15mg

1. Synthroid 75mcg qd

Answer: _____

Pyridium phenazopyridine HCL Tablets USP 100mg

2. Pyridium 0.2g q8h

Answer: _____

SECTION 2

3. The physician has ordered the antibiotic Penicillin G Procaine 750 000 units IM q.i.d. Using the label below, how many ml will you administer?

Answer: _____

SECTION 3

The doctor orders a complex IV therapy regimen.

IV infusion	Bag #1:	D5W 1000 ml @ 110 ml/hr
Followed by:	Bag #2:	D5W/NS 500ml @ 100ml/hr
Followed by:	Bag #3:	NS 1000ml @ 70ml/hr

4. The first bag is to be started at 08:00 and run at 110ml/hr.
   The drop factor is 15gtts per ml.
   The I.V. should be regulated at how many drops per minute?

Answer: _____

5. At 1930 hours, which I.V. solution is running and how much of that bag should the
   client have received?

Answer: _____

SECTION #4

Calculate the rate at which you will run the following IV order.

6. 2500ml LR IV at 175ml/hr with a drop factor of 10gtts/ml

Answer: _____

SECTION 5

Mr. St Croix has the following Insulin and sliding scale orders:

- Humulin R 22 units SC at 07h30, 11h30, and 17h30
- Humulin N 15 units SC at 07h30 and 21h30
- Humulin R SC as per sliding scale at 07h30, 11h30, 17h30, and 21h30.

Insulin Sliding Scale

Insulin Dose	Glucose Reading (mmol/L)
No coverage	Glucose ≤ 12.0
4 units	12.1 – 14.0
6 units	14.1 – 16.0
8 units	16.1 – 18.0
10 units	18.1 – 20.0
Hold insulin and Call MD stat	Glucose more than 20.1

7. At 07h30, Mr. St Croix's blood glucose is 13.6. mmol/L. How much insulin should the nurse give now? Be specific.

Answer: _____

8. At 21h30, Mr. St Croix's blood glucose is 15.2 mmol/L. How much insulin should the nurse give now? Be specific.

Answer: _____

End of part B

Exam Number_____

NURSING 180-51J

PRACTICE MEDICATION ADMINISTRATION QUIZ
Surgical Component

(PART A)

Instructions:

1. Read and follow the directions for each question.

2. Show all calculations. If needed, show calculations on the back of the test pages. No additional paper will be allowed. When necessary, provide answers up to two (2) decimal points.

3. There are a total of 3 questions and 5 responses.

4. Your response must include all of the information required to completely answer the question.

5. Time allotted is 20 minutes.

6. When using a calculator you must still show how you set up the problem.

1. Mrs. Ahi developed a DVT postoperatively and a heparin drip was ordered according to the following protocol:

Doctor's order: i) Start infusion of **25,000 units of heparin in 250 mL D5W at 600 units/hour**
ii) Titrate subsequent dosages according to the following heparin protocol.

PTT (seconds)	**Bolus (units)**	**Stop infusion (minutes)**	**Rate change (mL/hour)**	**Repeat PTT**
<40	5000	0	+3	q6h
40-55.9	2500	0	+2	q6h
56-69.9	0	0	+1	q6h
70-90.9	0	0	0	q24h
91-120	0	0	-1	q6h
>120	0	60	-2	q6h

a) At what rate should the infusion pump be set when starting the heparin infusion?

2. Doctor's order: Solu Cortef 175 mg IV q8h

Administration instructions: Each dose of the medication must be diluted in 50 mL of IV solution and administered over 15 minutes.

a) Using the label provided, what volume of the reconstituted solution should the nurse draw up to administer the prescribed dose?

b) At what rate should the IV pump be set to administer the medication in the desired time?

c) The solu-cortef was discontinued and a new order below was written.
Doctor's order: Dexamethasone elixir 750mcg PO qam
Supplied: Dexamethasone elixir 0.5mg/5ml

What volume of Dexamethasone should be administered?

3. Doctor's order: Humulin R 6 units SC at 08h00
Humulin N 14 units SC at 08h00

Sliding scale Humulin R SC qid: 08h00-12h00-17h00-22h00
<10mmol/L→ 0 units
10.1-12.0 mmol/L → 2 units
12.1-14.0 mmol/L → 4 units
14.1-16.0 mmol/L → 6 units
16.1-18.0 mmol/L → 8 units
>18.0 mmol/L → call MD

a) At 08h00 the patient's blood glucose is 14.4 mmol/L. What type(s) and dosage(s) of insulin should be administered?

End of part A

Exam Number _____

NURSING 180-51J

PRACTICE MEDICATION ADMINISTRATION QUIZ
Surgical Component

(PART B)

Instructions:

1. Read and follow the directions for each question.

2. Show all calculations. If needed, show calculations on the back of the test pages. No additional paper will be allowed. When necessary, provide answers up to two (2) decimal points.

3. There are a total of 3 questions and 5 responses.

4. Your response must include all of the information required to completely answer the question.

5. Time allotted is 20 minutes.

6. When using a calculator you must still show how you set up the problem.

1. Mr. Andrews developed a DVT postoperatively and a heparin drip was ordered according to the following protocol:

Doctor's order: i) Start infusion of **25,000 units of heparin in 250 mL D5W at 800 units/hour**

ii) Titrate subsequent dosages according to the following heparin protocol.

aPTT (seconds)	**Bolus (units)**	**Stop infusion (minutes)**	**Rate change (mL/hour)**	**Repeat aPTT**
<40	5000	0	+3	q6h
40-55.9	2500	0	+2	q6h
56-69.9	0	0	+1	q6h
70-90.9	0	0	0	q24h
91-120	0	0	-1	q6h
>120	0	60	-2	q6h

a) At what rate should the infusion pump be set when starting the heparin infusion?

2. Doctor's order: Solu-Medrol 175 mg IV q8h

Administration instructions: Each dose of the medication must be diluted in 50 mL of IV solution and administered over 20 minutes.

c) Using the label provided, what volume of the reconstituted solution should the nurse draw up to administer the prescribed dose?

d) At what rate should the IV pump be set to administer the medication in the desired time?

c) The Solu-Medrol was discontinued and a new order below was written.

Doctor's order: Prednisolone oral solution 150mcg PO qam
Supplied: Prednisolone oral solution 0.5mg/5ml

What volume of Prednisolone should be administered?

3. Doctor's order: Humulin R 10 units SC at 08h00
Humulin N 8 units SC at 08h00

Sliding scale Humulin R SC qid: 08h00-12h00-17h00-22h00
<10mmol/L→ 0 units
10.1-12.0 mmol/L → 2 units
12.1-14.0 mmol/L → 4 units
14.1-16.0 mmol/L → 6 units
16.1-18.0 mmol/L → 8 units
>18.0 mmol/L → call MD

b) At 08h00 the patient's blood glucose is 13.4 mmol/L. What type(s) and dosage(s) of insulin should be administered?

End of part B

Exam number_____

NURSING 51J
PRACTICE MEDICATION ADMINISTRATION QUIZ
Pediatric

(PART A)

Instructions:

1. Read and follow the directions for each question.

2. Show all calculations. If needed, show calculations on the back of the test pages. No additional paper will be allowed. When necessary, provide answers up to two (2) decimal points.

3. There are a total of 2 questions and 5 responses.

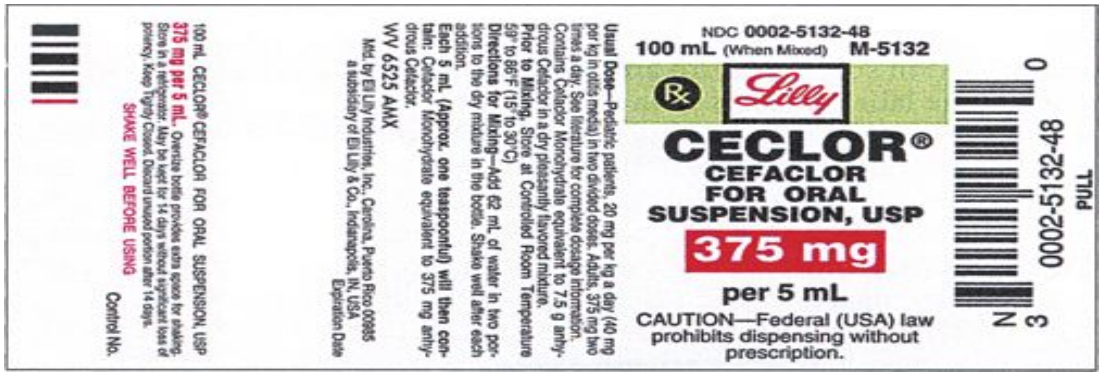
4. Your response must include all of the information required to completely answer the question.

5. Time allotted is 20 minutes.

6. When using a calculator you must still show how you set up the problem.

Question 1

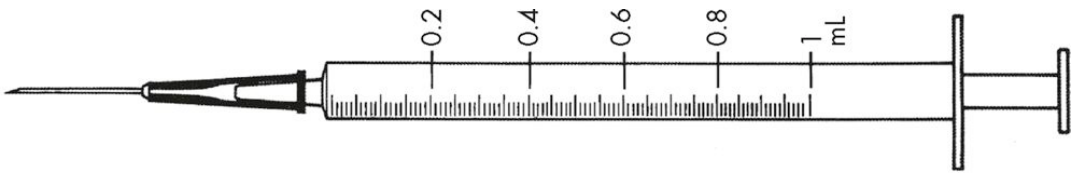
Doctor's order: Cefaclor 70 mg PO q8h
Supplied: See label below
Recommended dosage: 20-40 mg/kg/day PO q8h
Patient's weight: 11.5 kg



a) Is this a safe dosage for this child?

b) What volume of medication should be withdrawn to administer the ordered dose? Show your calculations.

c) Indicate this volume on the syringe below.



Question 2

Pauline, a 10 year old who weighs 42kg, is admitted for undiagnosed knee pain.

Doctor's order: Acetaminophen 630 mg PO q4h prn
Supplied: Acetaminophen 75 mg/mL
Recommended single dose: 10-15 mg/kg/dose PO/PR q4 -6h prn
Maximum daily dose: 75mg/kg/day, maximum of 5 doses/day

a) Is this a safe dose for this child?

b) What volume of acetaminophen should be administered?

End of part A

Exam number_____

NURSING 51J
PRACTICE MEDICATION ADMINISTRATION QUIZ
Pediatric

(PART B)

Instructions:

1. Read and follow the directions for each question.

2. Show all calculations. If needed, show calculations on the back of the test pages. No additional paper will be allowed. When necessary, provide answers up to two (2) decimal points.

3. There are a total of 2 questions and 5 responses.

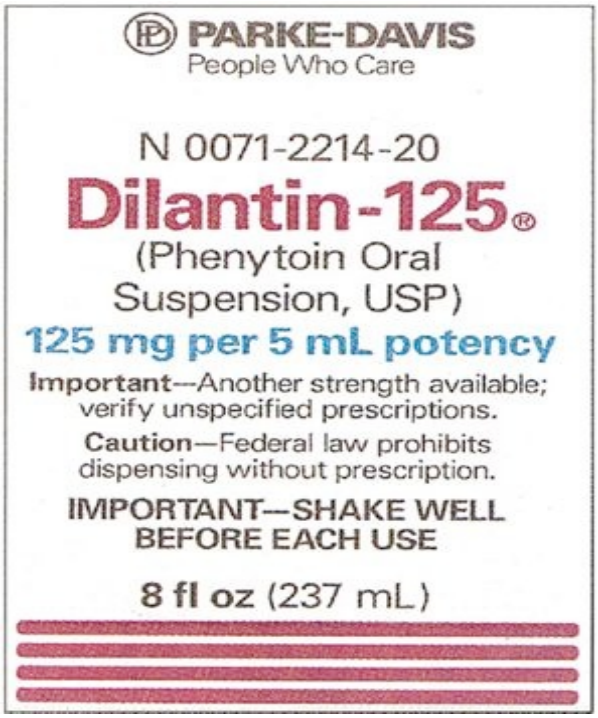
4. Your response must include all of the information required to completely answer the question.

5. Time allotted is 20 minutes.

6. When using a calculator you must still show how you set up the problem.

Question 1

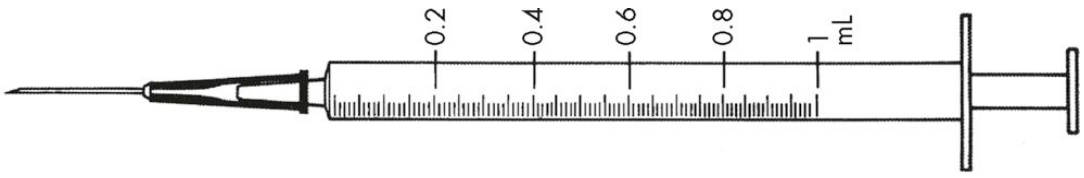
Doctor's order: Dilantin 12mg PO q8h
Supplied: See label below
The recommended dosage: 4-8 mg/kg/day q8h
Patient's weight 11.5 kg.



a) Is this a safe dose for this child?

b) What volume of medication should be withdrawn to administer the ordered dose? Show your calculations.

c) Indicate this volume on the syringe below.



Question 2

Batiste, an 8 year old who weighs 32kg, is admitted for undiagnosed knee pain.

Doctor's order: Acetaminophen 480 mg PO q4h prn
Supplied: Acetaminophen 75 mg/mL
Recommended single dose: 10-15 mg/kg/dose PO/PR q4 -6h prn
Maximum daily dose: 75mg/kg/day, maximum of 5 doses/day

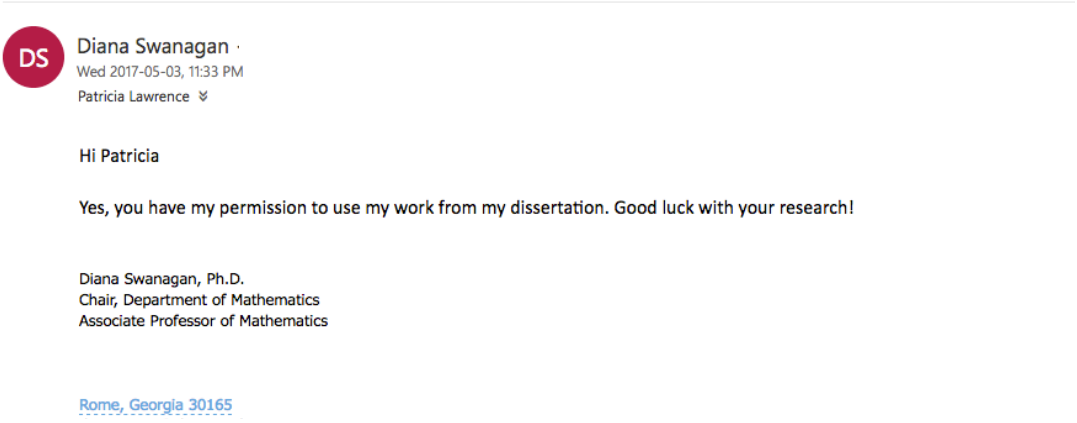
a) Is this a safe dose for this child?

b) What volume of acetaminophen should be administered?

End of part B

APPENDIX C

AUTHORIZATION FOR USE OF MATHEMATICS SELF-EFFICACY AND ANXIETY QUESTIONNAIRE.



DS

Diana Swanagan

Wed 2017-05-03, 11:33 PM

Patricia Lawrence

Hi Patricia

Yes, you have my permission to use my work from my dissertation. Good luck with your research!

Diana Swanagan, Ph.D.
Chair, Department of Mathematics
Associate Professor of Mathematics

Rome, Georgia 30165

APPENDIX D

MATHEMATICS SELF-EFFICACY AND ANXIETY QUESTIONNAIRE.

Adapted for this study with permission from the author Diana K. May.

In order to better understand what you think and feel about drug calculations and to get an understanding of your mathematics background and experience with calculators, please respond to each of the following statements. Write the number of your MAQ in the space provided so that your questionnaire responses can be matched to your MAQ. All responses will be confidential and will remain anonymous. If you do not wish to participate in this research please circle "Non participant."

Number of your MAQ _____ Non-participant

SECTION I

Where did you complete your high school mathematics?

Quebec English Sector
Quebec French Sector
Other Canadian Province
Outside of Canada
Outside North America

What was the level of the highest mathematics course you have taken?

High School
College
University Undergraduate
University Graduate
Other

If used, list the strategies you find helpful when trying to solve a drug calculation problem? E.g. visualization, write formula, drawing pictures, etc.

_____

_____

Before solving a drug calculation problem do you estimate what your answer will be?

Never
Seldom
Sometimes
Usually
Always

After solving a drug calculation problem do you think about whether your answer makes sense?

Never
Seldom
Sometimes
Often
Usually

How comfortable are you with using a basic calculator?

Uncomfortable
Somewhat uncomfortable
Comfortable
Somewhat comfortable
Very comfortable

What was your grade on your first attempt at the previous semester's MAQ?

Over 90%
Between 90-80%
Between 80-70%
Between 70-60%
Below 60%

Continue on next page

SECTION II	Never	Seldom	Sometimes	Often	Usually
1. I feel confident enough to ask questions when drug calculations are being taught	1	2	3	4	5
2. I get tense when I prepare for a drug calculation test	1	2	3	4	5
3. I worry that I will not be able to use drug calculations as a nurse when needed	1	2	3	4	5
4. I worry that I will not be able to get a good grade on the drug calculation test	1	2	3	4	5
5. I worry that I will not be able to do well on drug calculation tests	1	2	3	4	5
6. I believe I will be able to use drug calculations as a nurse when needed	1	2	3	4	5
7. I feel stressed when listening to the explanations of the drug calculation teacher	1	2	3	4	5
8. I believe I can understand the content in a drug calculation class	1	2	3	4	5
9. I believe I can get 80% in the drug calculation test	1	2	3	4	5
10. I feel confident when taking a drug calculation test	1	2	3	4	5
11. I feel more confident when performing drug calculations with a calculator	1	2	3	4	5
12.I feel I will do better in future drug calculation tests when I cannot use a calculator	1	2	3	4	5
13.I feel more confident I can get 80% on a drug calculation test with a calculator	1	2	3	4	5
14.Without the use of a calculator I feel I will do better on drug calculations in the clinical setting	1	2	3	4	5
15.I worry more when performing drug calculations with a calculator	1	2	3	4	5
16.I worry more that I will not do well in future drug calculation tests when I cannot use a calculator	1	2	3	4	5
17.I worry less about getting 80% on a drug calculation test with a calculator	1	2	3	4	5
18.Without a calculator I worry less that I will be able to carryout drug calculations in the clinical setting	1	2	3	4	5

APPENDIX E

VERBAL INFORMATION TO BE GIVEN TO PARTICIPANTS

Prior to obtaining consent for participation in the study, students will be given the following verbal information.

Purpose:

Nurses use mathematical skills in many of their functions. However those skills are most needed for medication administration. The complexity of the drug calculations can increase in various clinical settings. Nurses in the clinical setting will often be observed using a calculator when computing drug dosages, to improve calculation outcomes.

It is also documented in the literature that nursing students have higher test anxiety than students in any other health science field. Approximately 50% of nursing students have math anxiety and their self-efficacy around math is generally low. High anxiety and low self-efficacy has been shown to negatively influence test outcomes.

The OIIQ has allowed the use of calculators in its licensing exam for several years and nurses are allowed to use calculators in the work place when needed. However, it was only in the winter of 2017 that the second and third year students in the John Abbott Nursing program, were allowed to use the calculator in quizzes, exams, and in the clinical setting. In the literature the use of calculators in nursing schools for drug calculations is controversial and inconclusive, and its effect on drug calculation anxiety and self-efficacy has not been studied. Finding ways to improve your drug calculation accuracy will directly affect the care you give to your patients throughout your career.

My research will benefit you, future students, and the entire nursing program. Your feedback and contributions will guide the development of strategies to improve overall drug calculation outcomes, in particular those not met by the use of a calculator. The immediate benefit to you is an opportunity to practice for your MAQ and to seek remediation before your actual MAQ this semester. Your clinical teacher will review the MAQ with you during clinical conference.

Participation in the study will include:

Students who participate in this study will take a practice Medication Administration Quiz (MAQ) that will not count for marks. It will be held outside of class time (date, time and room number to be determined based on F2017 schedule). The PMAQ will consist of two parts. The first part must be completed without a calculator and the second with a calculator. Each part will be 20 minutes long. At the end of the second part of the PMAQ you will complete a questionnaire electronically. You will have 10 minutes to complete the questionnaire. All MAQ's, questionnaires and grading grids will be coded numerically. There will be no way to link any of the

data to individual students as a unique code/identifier will be used to replace the student's name/student #. All information will be kept confidential. Participation or non-participation in the study will not impact your grade in the course.

APPENDIX F

CONSENT FORM

Drug Calculation: Do Calculators Make a Difference for Nursing Students?

Researcher:	Patricia Lawrence	Tel: Ext.
Email address:		
Dept /Affiliation:	Nursing	
Supervisor:	Christina Clausen	Tel: Ext.

You are being invited to participate in this research study that is designed to look at the effect of calculator use on drug calculation outcomes. You are part of the cohort of students who are newly permitted to use calculators during the Medication Administration Quiz and on the clinical unit. It is important that you read the following information and ask as many questions as is necessary in order to understand what you can expect should you decide to participate. It is also important that you understand that you do not have to take part in this study.

Research Questions (if applicable):

Question: "What is the effect of calculator use on drug calculation outcomes for 2nd and 3rd year nursing students enrolled in a nursing program at the CEGEP level?

Specifically:

1. Does calculator use result in a difference in math self-efficacy?

2. Does calculator use result in a difference in math test anxiety?

3. Does calculator use result in a difference in drug calculation outcomes?

4 Does calculator use result in a difference in math conceptualization skills?

Purpose of the research:

Numeracy is an essential skill used by nurses to perform several of their routine functions safely. However, those skills are most needed for medication administration since nurses spend 40% of a shift preparing medication (Mackie & Bruce 2016). To ensure that students have achieved the mathematics skill level required to safely prepare medications, nursing schools require them to take a drug calculation test before graduating. Students are generally anxious about the MAQ and express low

self-esteem. The use of calculators for the MAQ was instituted in the JAC nursing program in W2017. The purpose of this research is to explore the effect of using a calculator on the student's anxiety and self-efficacy related to the drug calculation test, as well as its effect on drug calculation arithmetic outcomes and conceptualization skills. The results of this research could be used to guide the development of strategies to improve overall drug calculation outcomes for our nursing students.

What is involved in participating?
If you agree to participate in this study you will:

- Take a practice Medication Administration Quiz (PMAQ) that will take place outside of class time during a common free period and will not count for marks. The quiz will reflect the difficulty of drug calculations expected for your semester and clinical rotation and will consist of three parts. Part A must be completed without the use of a calculator. Calculators will be provided for you to complete part B. Part C is a short survey aimed at gathering information about anxiety and self-efficacy around drug calculations as well as any precipitating factors. Parts A, B and C will each last 20 minutes. The PMAQ will be 1hr long.

- You will have an opportunity to review your PMAQ with your clinical teacher in the clinical setting, before you take the required MAQ, which counts for marks.

How long will the data collection stage take?
Data collection is expected to take place during the Fall 2017 semester. If you are in your second year of the program, you will have only one PMAQ. If you are in third year then you will take a total of two PMAQ's. The PMAQ will take place one week before each of your actual MAQ's that counts for marks.

Are their any potential risks or discomforts that I can expect from this study?
The PMAQ will simulate your actual MAQ and will be written under exam conditions. This may cause you some anxiety but it should be no more than is expected for any other exam. Should you exhibit anxiety beyond what can be normally expected for a test situation, you will be accommodated in the student access center.

Are their any potential benefits if I participate?
You will benefit directly from the participation in this research as it gives you an opportunity to practice for the MAQ, and to identify areas that you would need to work on. It also provides you with the opportunity to discuss your drug calculations with your clinical teacher. Knowledge gained from this study may be used to guide

other studies on the development of strategies to improve drug calculation outcomes for nursing students.

Cost and compensation.
You will not receive any compensation for your participation in this study.

Will information about me and my participation be kept confidential?

- There will be no way for anyone reading the results of this study to be able to link any data with your name or student number. PSEUDONYMS WILL ALWAYS BE USED in any publications that may result from this study, as well as in the stored data. If you withdraw from participation at a later date, all data of any kind will be erased and/or destroyed.
- Participation, or lack of participation in this research will NOT affect your grades in any way.
- Your participation is entirely voluntary and you may choose to withdraw at anytime.

Confidentiality means that no person at John Abbott College, or any other organization will have access to the materials collected and that they will be coded and stored in such as way as to make it impossible to identify them directly with any individual. All names will be changed in the stored data and resulting publications. Data will be stored on a password secured hard drive, and will be destroyed after a minimum of 2 years. All other type of information (audio-tapes, cd's, paper copies) will be stored in a locked filing cabinet and will be erased and/or destroyed after 2 years.

STUDENTS: please tick the appropriate box, sign, date and return to the teacher.

☐ I have read and understood the information provided on the consent form, and I agree to participate in this study. I understand that my participation is voluntary, I may withdraw from participation at any time, and my academic standing will NOT be affected in any way by consenting or not consenting to participate in this study.
☐ I do not consent to participate in the described study.

Student's name (print):

_____
First name, Last name

Student's signature: _____ Date: _____
signature dd / mm / yyyy

Researcher's signature: _____Date: _____

signature dd / mm / yyyy

IF STUDENT IS UNDER THE AGE OF 18, PLEASE FILL OUT THIS SECTION AS WELL:

☐ I have read and understood the information provided on the consent form, and I agree that my daughter or son may participate in this study. I understand that their participation is voluntary, they may withdraw from participation at any time, and their academic standing will NOT be affected in any way by consenting or not consenting to participate in this study.

☐ I do not consent for my daughter or son to participate in the described study.

Parent's or legal guardian's name (print): First name, Last name _____

Parent's or legal guardian's signature: _____ Date: _____

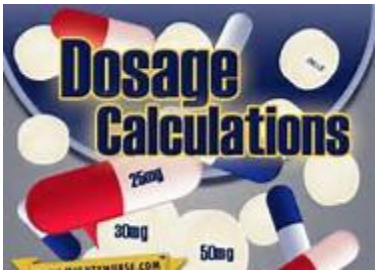
signature dd / mm / yyyy

Researcher's signature: _____Date: _____

signature dd / mm / yyyy

APPENDIX G

WRITTEN INFORMATION TO BE GIVEN TO PARTICIPANTS



Nurses use mathematical skills in many of their functions. However those skills are most needed for medication administration. The complexity of the drug calculations can increase in various clinical settings. Nurses in the clinical setting will often be observed using a calculator when computing drug dosages, to improve calculation outcomes.

It is also documented in the literature that nursing students have higher test anxiety than students in any other health science field. Approximately 50% of nursing students have math anxiety and their self-efficacy around math is generally low. High anxiety and low self-efficacy has been shown to negatively influence test outcomes.

The OIIQ has allowed the use of calculators in its licensing exam for several years and nurses are able to use calculators in the work place when needed. However, it was only in the winter of 2017 that the second and third year students in the John Abbott Nursing program, were allowed to use the calculator in quizzes, exams and in the clinical setting. In the literature the use of calculators in nursing schools for drug calculations is controversial and inconclusive and its' effect on drug calculation anxiety and self-efficacy has not been studied.

Finding ways to improve your drug calculation accuracy will directly affect the care you give to your patients through out your career.

Patricia

APPENDIX H

COPY OF APPLICATION TO ETHICS COMMITTEE

Research Proposal: Summary Document

Name: Patricia Lawrence Date: 10th May 2017

Address

Email Address

Telephone Number(s) mobile JAC

1. ELEMENTS OF THE PROPOSED RESEARCH PROJECT

1.1 Location(s) of Study:
The study will be conducted in the Nursing Department at John Abbott College. It is not an inter-college project.

1.2 Title of Research Project
Drug Calculation: Do Calculators Make a Difference for Nursing Students?

1.3 Statement of Purpose

Numeracy is an essential skill used by nurses to perform several of their routine functions safely. It is defined as the ability to conceptualize the problem and to calculate and accurately interpret the results obtained (Mackie & Bruce, 2016). It is used to monitor the fluid balance of the patient as well as to regulate the flow of intravenous fluid. However mathematical skills are most needed for medication administration, since nurses spend 40% of a shift preparing medication (Mackie & Bruce 2016). Nurses are expected to calculate and verify medication dosages each time they administer a medication. They provide the last verification that the right dose of the medication is prescribed and that the correct amount of medication to deliver this dose, is prepared and administered. This requires basic mathematic skills such as multiplication and division, but when this is coupled with fractions, decimals and unit conversions, for some nurses this becomes a computation nightmare (Mackie & Bruce, 2016).

The complexity of the drug calculations can increase in various clinical settings. For example, when the nurse is caring for newborns and children, preparation errors increase in frequency 27% to 60% (Bagnasco et al., 2016). Errors in dosage calculations can cause serious harm to the patient and in some cases death (Mackie & Bruce, 2016; McMullan, 2012). To improve calculation outcomes, nurses in the clinical setting will often be observed using a calculator when computing drug dosages.

To ensure that students have achieved the mathematical skill level required to safely prepare medications, nursing schools require them to take a drug calculation test before graduating. This test usually requires that students achieve a high percentage to pass. Failure may mean an inability to complete the program or at least a delay in graduation (Roykenes, Smith & Larsen, 2014).

Students come to the John Abbott College (JAC) nursing program from diverse cultural and educational backgrounds and their numeracy skills are varied. Some have not worked with fractions or decimals for a number of years or have grown accustomed to using calculators to solve math problems. They worry about their basic math skills, with some students stating that they are just not good with math.

In each of the six semesters of the JAC nursing program, students receive instruction on the type of drug calculations they are expected to perform during that semester. A medication administration quiz is then administered to test student's safety for drug administration. Anecdotally student anxiety around these drug calculation tests is generally high. In the weeks and days before the test, students spend hours in teachers' offices or in tutoring, practicing questions and reviewing how to work with fractions and decimals and how to perform long division. Their anxiety is high and their self-efficacy low. This agrees with research from Shapiro (2014) who found that test anxiety in nursing students is higher than students in other health disciplines. Walsh (2008) also reported that the self-efficacy of nursing students related to solving math problems is low. Students who fail the test because of errors related to the use of fractions and placement of the decimal are often frustrated.

The use of calculators in drug calculations is controversial. In one study no significant difference was found in drug calculation outcomes when a calculator was used (Tarnow & Werst, 2000). Conversely, other studies found that calculators improved basic math calculation outcomes (Bagnasco et al., 2016; Pentin & Smith, 2006) but increased errors related to the conceptualization of the problem (Shockley et al., 1989). Conceptualization is important as it guides the students to the mathematical functions required to solve the drug calculation. It is also used in determining if the result is realistic for the context in which the medication will be given.

Since drug calculations are so important to patient safety and the literature results inconclusive, the effect of calculator use on math calculation outcomes and conceptualization skills is warranted (Shockley et al., 1989; Dopson, 2008). The relationship between the use of the calculator, and anxiety and self-efficacy related to math, is also unclear. This study therefore, explores the effect of using a calculator on the student's anxiety and self-efficacy related to the drug calculation test, as well as its effect on drug calculation arithmetic outcomes, and conceptualization skills.

1.4 Type of Research Design (e.g. content analysis, questionnaires, interviews, experiment, observation, use of available statistics)

A quasi-experimental design will be used with a convenience sample of students enrolled in the second and third year of the JAC nursing program in Fall 2017.

Procedure

The winter 2017 semester is the first time that the second and third year nursing students will be allowed to use calculators during the drug calculation test called a "Medication Administration Quiz" (MAQ) at John Abbott College. The first year students however, must still take this quiz without using calculators. A practice medication administration quiz (PMAQ) will be administered in the third week of the semester, before the students write their actual MAQ in week four, which counts towards their final grade. The students will have already received instruction in weeks one and two on the type of drug calculations they will be expected to perform in their respective semesters. The PMAQ will consist of two parts, part A and part B which will be randomly distributed to the participants so approximately half of the students will start with part A and finish with part B and the other half begin with part B and end with part A. The first part received will be completed without a calculator and the second part received will be completed with a calculator (Appendix A). Both parts of the quiz require the level of conceptualization and computation skills appropriate for the semester and clinical rotation of the student. Students will be required to submit the first part before they are given the second part. Both parts A and B will be analyzed for computation errors by looking at the number of questions answered correctly. They will also be analyzed for conceptualization errors by differentiating an arithmetic error e.g. addition, subtraction, multiplication and division from errors in setting up the problem e.g. setting up the problem as a division when it should be a multiplication. Relationships between calculator use and both computation errors and conceptualization errors will be analyzed using MANOVA with α set at $p \leq 0.05$. Students will be given the opportunity to review their exam with their clinical teacher and to seek remediation if needed, before they take the MAQ that counts towards their final grade.

Once they have finished writing the second part of the quiz, students will anonymously complete the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) electronically (Appendix B). The MSEAQ uses a 5-point Likert-type scale and consists of 18 questions. Questions related to students familiarity with calculators and math background are also included. The PMAQ will last a total of 40 minutes with the first and second parts having a duration of 20 minutes each. An additional 20 minutes will be allotted for the completion of the MSEAQ survey.

Students in 3rd year switch clinical rotations halfway through the semester and take another MAQ corresponding to the new clinical rotation. The PMAQ will therefore be repeated for the 3rd year students in week 10, one week before they take their second MAQ. This is to ensure equality of preparation for all the students for each MAQ.

- The dosages in both the doctors orders and the medication available in the PMAQ part A will be changed to create PMAQ part B
- PMAQ part A and PMAQ part B will be compared to ensure that the level of difficulty of the questions remains consistent.

1.5 Description of Population and Sample

The participants for this study will include a convenience sample of approximately 90 second year and 60 third year nursing students enrolled in the day division nursing program at John Abbott College in Fall 2017. Students come to the John Abbott College (JAC) nursing program from diverse cultural and educational backgrounds and their numeracy skills are varied. Some have not worked with fractions or decimals for a number of years or have grown accustomed to using calculators to solve math problems. Although students are predominantly female, there are a few male students in each cohort. The majority of the students come directly from high school but there is a significant number who are returning to school after having pursued other interests.

1.6 Method of Recruitment of Participants

All students registered in their second and third year of nursing in Fall 2017 will be invited to participate in this study. The primary researcher will provide all students with information about the study both verbally and in an information letter (Appendix C) during the first week of the semester.

1.7 Remuneration, if applicable

There will be no remuneration given for participation in this study.

1.8 Verbal and Written Explanation to be Given to the Participants

A research assistant will provide the study information, explain the study and conduct the consent process. A verbal explanation of the purpose of the study and the potential benefits to them as well as the nursing department will be given (Appendix C). A complete explanation of what participation in this study entails will be given, questions will be answered and discussion permitted so that participants can give informed consent. Students will be assured that strict confidentiality will be observed. All practice MAQ's, questionnaires, and data collected from these instruments will be coded numerically to protect participant anonymity. If the student chooses to withdraw from participation at a later date, all data of any kind related to that student will be erased and/or destroyed. These results will not affect the student's overall grade in the course. Students may withdraw from the study at any time.

1.9 Role of the Participants (including activities to be done and time required)

Students who participate in this study will take a practice Medication Administration Quiz (MAQ) that will not count towards the final grade. It will be held outside of class time during a common free period. The PMAQ will consist of two parts. The first part must be completed without a calculator and the second with a calculator. Each part will be 20 minutes long. At the end of the second part of the PMAQ students will complete a questionnaire using clickers or another electronic device (still to be determined). If clickers are used, the researcher will provide them. If an electronic device needing Wi-Fi accesses is needed, students will be allowed to

use their own devices. For those who do not have such a device, one will be discreetly provided. They will have 20 minutes to complete the questionnaire.

1.10 Evaluation of the Potential Benefits and Risks

There are no anticipated risks to the participants however, students will benefit by having an opportunity to practice for their actual MAQ and to seek remediation if necessary before taking the required MAQ, which counts towards their final grade. Students may experience some anxiety as the PMAQ will take place under exam conditions but this anxiety should be no more than would be normally expected in their regular MAQ. Should any student exhibit anxiety beyond what can be normally expected for a test situation, the student will be accommodated in the student access center.

1.11 Methods of Data Collection

All data will be securely stored for a minimum of two years following completion of the study (or time period specified by the college). Subsequent to this, all completed questionnaires will be shredded, and electronic data will be deleted.

1.12 Instrumentation (interview questions, questionnaires, experimental design, etc.) (attached as an appendix)

The MSEAQ was originally developed by Diana K May now Swanagan to look at the relationship between mathematics self-efficacy and mathematics anxiety. The questionnaire was developed and reliability and validity determined by using an exploratory factor analysis design. It consisted of 29 items but only 28 were used in the analysis, as one item was not functioning as expected. The 28-item questionnaire has a Cronbach alpha of .96 indicating a good internal reliability. The MSEAQ results were comparable to those of other established mathematics self-efficacy and mathematics anxiety questionnaires.

The MSEAQ was adapted for this study by changing the word “mathematics” to “drug calculation” and by adding “with a calculator” or “without a calculator” to a few items. The number of items in the questionnaire was also reduced to 18. Permission to use the MSEAQ was granted by Diana K Swanagan on May 3rd 2017 via email.

See appendix A and B for PMAQ A and survey questions.

- The dosages in both the doctors orders and/or the medication available and/ or the drug names in the PMAQ part A will be changed to create PMAQ part B
- PMAQ part A and PMAQ part B will be compared to ensure that the level of difficulty of the questions remains consistent.

1.13 Expectations of the College to Provide Materials and/or Services

The calculators and clickers (if used) already exist in the nursing department for use as teaching tools. No additional materials or services from the college will be need for this research.

2. ADDRESSING POTENTIAL ETHICAL CONCERNS

2.1 Informed consent

Students will be involved in the research process from the beginning in an attempt to ensure free and informed consent (Appendix D). Prior to obtaining consent, the goals of the research project will be explained by the primary researcher along with the potential benefits (as they are known) of participation in the research project. Open discussion regarding the goals and benefits will be encouraged and students will be made aware of the value of their contributions and the impact it may have on future educational experiences of a similar nature. Further, students will be made aware that research results will be shared with them.

Another faculty member (referred to as the research assistant) will obtain consent at the time of the PMAQ. The primary researcher will not be present in the classroom when consent is obtained. The research assistant will give all completed consent forms to the Nursing Department's Administrative Technician who has agreed to keep them securely stored until the term of the study is over. The primary researcher will remain unaware of student participation until the term is over. No manipulation, undue influence or coercion will be used to enlist student participation. Students will be informed that no marks are allocated for participation in the research project and there will be no adverse consequences for non-participation. Consent will be obtained in a manner such that choice of participation in the project will not be public knowledge (during the study all students will be given a MSEAQ to complete electronically; if a student chooses not to participate they can select the non-participant option on the survey). Where a student is a minor, parental consent will be obtained before entry into the study is permitted.

2.2 Privacy and confidentiality

A. All MAQ's and electronic questionnaires will be numbered. The Nursing Department's Administrative Technician will keep a master list of student names and their association to the numbered MAQ and questionnaire, confidential and secure. This procedure will be done with each MAQ and with the electronic submission of the MSEAQ questionnaire.

B. Data obtained from all MAQ's and questionnaires (individual and summative participant scores) will be imputed into SPSS for analyzing and will be password protected. Individuals having knowledge of this password will only be those involved in data analysis. All MAQ's and their marking rubric will be stored under lock and key in the secured room filing cabinet drawer (to be designated) of the nursing department at John Abbott College.

C. The primary researcher and those involved in data analysis will be the only individuals having access to the data. The primary researcher will be in charge of data analysis. Assistance will be requested from an external consultant regarding inputting data into excel and also with final decisions regarding specific descriptive and inferential statistics to analyze the data following collection.

D. All data will be securely stored for a minimum of two years following completion of the study (or time period specified by the college). Subsequent to this, all completed questionnaires will be shredded, and electronic data will be deleted.

2.3 Deception, if applicable

Not applicable

2.4 Post-study explanation and/or debriefing, if appropriate

Any concerns or issues resulting from the PMAQ performance will be addressed with the clinical teacher who is providing remediation.

2.5 Responsible dissemination of results of study

Results will be communicated in written format with the submission of the final paper. Results will also be shared with all faculty within the nursing department through an oral presentation during a regularly scheduled faculty or curriculum meeting (if time can be allocated) or through a time arranged by the primary researcher. The results will also be available to the students on a request basis.

2.6 Anticipated secondary use of the data

It is hoped that the findings of this research paper will identify implications for future education, practice, and research regarding enhancing student success with drug calculation. Results will provide a more comprehensive understanding of anxiety and self- efficacy in relation to math skills and calculator use. This research may assist other nursing schools both in Canada and around the world to develop strategies to improve drug calculation outcomes for their students. It is therefore the hopes of the primary researcher to have the results of this study published. As such, potential future researchers may request access to data for re-analysis or replication. In such cases, any secondary access to the data will not include access to any personal identifiers of participants in the original study.

2.7 management of storage and disposal of collected data

Please refer to 2.2D

APPENDIX I

APPROVAL LETTER

JOHN ABBOTT
CEGEP/COLLEGE

Certificate of Ethics Approval

Date:	June 8, 2017
School /Academic	CEGEP John Abbott College, Dept Nursing
unit: Title of project:	Drug Calculation: Can Calculators Make a Difference for Nursing Students?
Names & Titles of project research team members:	Researchers : Patricia Lawrence, CEGEP John Abbott College
Affiliation	x JAC researcher x MTP Research -- EXTernal research
Email address:	
Phone:	(Home) (Cell) (Work)

The members of the John Abbott College Research Ethics Board have examined the application and consider the experimental procedures as outlined by the applicant to be on acceptable on ethical grounds for research involving human participants. A final report summarizing the findings should be submitted to John Abbott College within six months of the completion of the study.

This project has been approved for the period of : 1 year	From:	08-06-2017 dd – mm - yyyy	To:	07-06-2018 dd – mm - yyyy

Certificate number:	JACREB201704	This approval of research ethics does not guarantee that CEGEP John Abbott College will provide access to any institutional services, such as Data Mining.

Co-Chairs of REB of CEGEP John Abbott College	Laura Shillington and Shireef Darwish		
Signature:		Date:	08-06-2017 dd – mm - yyyy